Director, Operational Test and Evaluation

2014 Assessment of the Ballistic Missile Defense System (BMDS)

March 2015

This report satisfies the provisions of the National Defense Authorization Act for Fiscal Year 2002, Section 232 (h), as amended by subsequent Acts, which mandates that the Director, Operational Test and Evaluation annually characterize the operational effectiveness, suitability, and survivability of the BMDS, and its elements, that have been fielded or tested before the end of the preceding fiscal year. The Act also requires the Director to assess the adequacy and sufficiency of the BMDS test program during the preceding fiscal year. This report is unclassified. Supplemental information is contained in classified appendices to this report.

J. Michael Gilmore
Director

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Executive Summary

This report assesses the Ballistic Missile Defense System (BMDS), its combat systems, and its sensor/command and control architecture. The four autonomous combat systems are the Ground-based Midcourse Defense (GMD), Aegis Ballistic Missile Defense (BMD), Terminal High-Altitude Area Defense (THAAD), and Patriot. The sensor/command and control architecture is anchored by the Command and Control, Battle Management, and Communications (C2BMC) element. The report covers the period of October 1, 2013, through December 31, 2014.

After a brief overview of the BMDS and its elements, the tests conducted during fiscal year (FY) and calendar year (CY) 2014 are summarized and followed by a characterization of the BMDS operational effectiveness, operational suitability, and survivability. Next, an evaluation of critical attributes of the test program and their associated measures of merit is presented for each threat missile class.[1] Recommendations are included in the Executive Summary. Associated with this report are three appendices presenting supplemental classified information for the three main sections of the report. A fourth classified appendix summarizes GMD flight test over the last five years and how the Homeland Defense assessment has evolved. This executive summary covers just the unclassified information. A classified executive summary is included under separate cover with the appendices and provides a single, comprehensive coverage of the entire FY/CY14 assessment.

The Missile Defense Agency (MDA) conducted eight flight tests and five ground tests during FY/CY14. Data from a ninth flight test, the first system-level operational test, Flight Test, Operational-01 (FTO-01, FY13) were also analyzed during the year. These tests were in accordance with the MDA-generated and Director, Operational Test and Evaluation (DOT&E)-approved Integrated Master Test Plan (IMTP), version 13.1, and as subsequently modified.[2]

Similar to previous BMDS reports, the assessments in this report are limited to the amount of test data that are available and the resulting limited verification, validation, and accreditation (VV&A) of the required BMDS modeling and simulation (M&S). As the MDA executes the IMTP during the next several years, additional test data supporting quantitative assessments should become available. It will take several more years to collect the test data needed to adequately VV&A the BMDS M&S required to perform such assessments. As data are collected, assessments will incrementally become more quantitative.

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1 The defense intelligence community classifies ballistic missile threats by range. Close-Range Ballistic Missiles (CRBMs) have ranges less than 300 kilometers; Short-Range Ballistic Missiles (SRBMs) have ranges from 300 to 1,000 kilometers; Medium-Range Ballistic Missiles (MRBMs) have ranges from 1,000 to 3,000 kilometers; Intermediate-Range Ballistic Missiles (IRBMs) have ranges 3,000 to 5,500 kilometers; and Intercontinental Ballistic Missiles (ICBMs) have ranges greater than 5,500 kilometers. CRBMs are treated as SRBMs in this report.

2 IMTP version 13.1 dated March 4, 2013; version 14.1 dated March 31, 2014; and version 14.2 dated September 22, 2014.

Operational Effectiveness, Operational Suitability, and Survivability

The maturity of the GMD weapon element, and the complexity and rigor of Homeland Defense-demonstrated testing, has not increased over the last five years due to deficiencies uncovered during three failed intercept attempts. Conversely, the maturity and testing complexity and rigor of the Regional/Theater weapon elements have generally shown improvement over the last five years. Table 1 defines and summarizes the key characteristics from lowest to highest level of demonstrated testing, technical rigor, test complexity, and operational realism. Table 2 shows the relationship between autonomous combat systems, their designed intercept phase, and the types of threats they will intercept in the specified phase of flight. In the case of Aegis BMD, the interceptor type is also shown. Each cell is color-coded according to its current demonstrated testing. Cells that are not colored indicate no capability against the particular threat class and are labeled “N/A” for “Not Applicable.” The cells that have a heavy line border are element versions that are currently deployed. Split cells show areas where the demonstrated capability has increased during FY14.

The MDA has demonstrated partial capability of the GMD combat system. GMD has demonstrated capability against small numbers of simple ballistic missile threats launched from North Korea and Iran, but a quantitative assessment is currently not possible. A quantitative assessment will require extensive ground testing that is supported by M&S accredited for performance assessment and grounded in flight testing. Such accreditation has not been completed. The reliability and availability of the operational Ground-Based Interceptors (GBIs) are low, and the MDA continues to discover new failure modes during testing. Several Exo-atmospheric Kill Vehicle (EKV) fixes were demonstrated in the most recent intercept flight test (Flight Test, GBI-06b (FTG-06b), FY14). The Capability Enhancement-I (CE-I) EKV experienced a flight test failure during FTG-07 in FY13. While the GBI was in flight, a voltage shift caused by battery electrolyte leakage shut down the flight computer and prevented EKV separation. The MDA developed and fully tested EKV software for CE-I GBIs, which included a capability to reset and recover the flight computer following a voltage shift. This software is now fielded to all deployed CE-I EKVs. Further, the MDA is developing new battery and ground ties, and once tested, plan to incorporate them into the CE-II Block 1 deliveries beginning in FY16. GMD demonstrations of survivability have been limited. The survivability characterization is based primarily on facility testing and component-level testing and suffers from significant data gaps.

Table 1. Demonstrated Testing Level Definitions

Level	Description and Key Characteristics			
	Accreditation of Models & Simulations	**Demonstrated Capability**	**Hardware/Software Components**	**Testing Rigor**
6	Autonomous combat system capability verified through integrated, operational test (OT), and independently accredited ground testing and/or models and simulations. The comprehensive set of defined weapon element requirements have been tested, and the combat system can be fully integrated into the BMDS. A credible and sustained combat capability has been demonstrated.			
	Independent Accreditation	Comprehensive	Full Operational Set with BMDS Integration	Integrated OT
5	Broad, but incomplete, demonstration of autonomous combat system capabilities through independently accredited ground testing and/or models and simulations. Accreditation is possible only if a sufficient quantity and quality of flight test data have been collected to support model verification and validation. Limited combat operations capability has been demonstrated.			
	Independent Accreditation	Broad but Incomplete	Full Operational Set	OT
4	Specific, limited autonomous combat system capabilities demonstrated through operationally realistic intercept flight testing with the full set of operational components. Flight testing emphasizes operational objectives over developmental test (DT). Ground testing and/or models and simulations need not be independently accredited and may be used for preliminary assessments. Emergency combat operations capability has been demonstrated.			
	Limited Accreditation	Specific/Limited/Operationally Realistic	Full Operational Set	Combined dt/OT
3	Specific, limited autonomous combat system capabilities demonstrated through flight testing with key operational components. Flight testing emphasizes developmental objectives over operational objectives. Flight test data obtained are expected to contribute to independent accreditation of models and simulations used for assessing performance.			
	No Accreditation Required	Specific/Limited	Key Operational Set	Combined DT/ot
2	Specific autonomous combat system capabilities demonstrated through developmental flight testing with developmental or legacy system hardware/software. The flight test data obtained support the development of engineering versions of models and simulations.			
	Engineering M&S	Specific	Developmental or Legacy	DT
1	Autonomous combat system concept defined with capabilities estimated through analysis, laboratory testing, and/or legacy system models and simulations.			
	Legacy M&S	Concept Only	Analysis, Laboratory, or Legacy	Laboratory

Table 2. Demonstrated Testing by Element, Intercept Phase, and Threat

Element	Intercept Phase	Threat Type			
		SRBM	MRBM	IRBM	ICBM
GMD Ground System 6B1.5 (GS 6B1.5)	Midcourse	N/A	N/A	3	3
Aegis BMD 3.6.1	Midcourse (SM-3)	5	4	4	N/A
	Terminal (SM-2)	4	N/A	N/A	N/A
Aegis BMD 4.0	Midcourse (SM-3)	4 ➡ 5	4 ➡ 5	1	N/A
Aegis Baseline 9.B1/C1	Midcourse (SM-3) Terminal (SM-2/-6)	1 ➡ 4	1	1 N/A	N/A
Aegis Baseline 9.B2/C2	Midcourse (SM-3)	1	1	1	N/A
THAAD Configuration 1	Terminal	5	4	1	N/A
THAAD Configuration 2	Terminal	3	4	1	N/A
Patriot Post-Deployment Build 6.5.2 (PDB-6.5.2)	Terminal	6	6	N/A	N/A
Patriot Post-Deployment Build 7 (PDB-7)	Terminal	6	6	N/A	N/A
Patriot Post-Deployment Build 8 (PDB-8)	Terminal	1	1	N/A	N/A

The Aegis BMD 4.0 system with SM-3 Block IB guided missiles completed Initial Operational Test and Evaluation in FY14. Testing has demonstrated that the Aegis BMD 4.0 system possesses a capability to engage non-separating and complex-separating SRBM threats, simple-separating MRBM, and lower-range threshold IRBM threats in the midcourse phase of flight using SM-3 Block IB guided missiles.[3] However, flight testing and M&S did not test the full range of expected threat types, threat ground ranges, engagement geometries, and threat raid sizes. Analysis of data obtained during flight testing and the maintenance demonstration showed

3 There are two basic missile types. One type is non-separating, in which the warhead payload (or re-entry vehicle) and the rocket body remain attached throughout the entire missile flight. The second type is separating, in which the re-entry vehicle separates from the missile body. Some separating missile threats employ a post-boost vehicle that separates from the rocket body and then reorients to fine-tune the re-entry vehicle trajectory before ejecting the re-entry vehicle. These missiles are referred to as complex-separating threats. If no post-boost vehicle is employed, then the missile is referred to as a simple-separating threat. CRBMs, SRBMs, and MRBMs can be either non-separating, simple-separating, or complex-separating missiles. All IRBMs and ICBMs are either simple- or complex-separating missiles.

that the Aegis BMD 4.0 system is suitable to meet availability specifications. Operational testers observed lower than desired command, control, communications, computers, and intelligence hardware reliability and undesirable BMD Signal Processor stability in early flight tests, but computed availability still meets the threshold value specified. SM-3 missile failures encountered during flight testing of the Aegis BMD 4.0 system that relate to the third-stage rocket motor (TSRM) have lowered certainty in the reliability of that SM-3 component.[4] The MDA established a Failure Review Board to determine the root cause of this failure and the Board uncovered enough evidence to determine that a re-design of the TSRM nozzle could improve missile reliability. New design concepts have been generated and initial ground testing of them began in FY14. An assessment of Aegis BMD 4.0 survivability under extreme environmental conditions is not possible. Testing to date occurred during available weather conditions, which in most cases did not reach stressing levels of rain, sea state, or other environmental conditions. Other environmental testing shortfalls that limit an assessment include tests to determine the effects of nuclear, biological, and chemical environments, as well as realistic testing conducted in a Global Positioning System-denied environment.

THAAD has demonstrated operational effectiveness against many short-range non-separating, short-range simple-separating, and medium-range targets. In 9 flight tests conducted between FY07 and FY13, THAAD intercepted all 10 target ballistic missiles (5 short-range non-separating ballistic missiles, 3 short-range simple-separating ballistic missiles, and 2 medium-range ballistic missiles). One flight test in FY09 demonstrated a salvo engagement and another flight test in FY12 demonstrated a multiple simultaneous engagement. However, a full characterization of effectiveness will require flight tests using the radar's advanced algorithms against more complex SRBM and MRBM targets and exploration of other parts of the battlespace relevant to longer/faster threats, and IRBM targets. The current THAAD personnel structure is not adequate to ensure timely and sufficient deployment and operation of a THAAD battery. In FY/CY14, the THAAD program made progress in resolving some of the 31 suitability-related conditions that the Army designated necessary for the system to improve following the conditional materiel release decision. However, completion of all 31 conditions is not currently scheduled until FY17. Two conditions that are ongoing and still require significant work include Soldier training and equipment reliability. The Army does not conduct sufficient training specific to THAAD, and necessary training aids and devices are not currently available and are not scheduled to become available for several years. Analyses of data from the Reliability Confidence Test and multiple flight tests suggest that the system components are not exhibiting consistent nor steadily increasing reliability between test events. The tools and diagnostic equipment available to Soldiers are insufficient to accurately emplace, maintain, and assess the operational status of THAAD equipment. The MDA subjected THAAD to natural environments testing, which included temperature extremes, temperature shock, humidity, rain, ice, snow, sand, dust, and wind, and found deficiencies in all areas except for wind.

4 The TSRM is common to both the SM-3 Block IA and SM-3 Block IB missiles.

Patriot meets the Capability Development Document's system effectiveness requirements against some tactical ballistic missiles. However, Patriot fails to fully meet requirements against other tactical ballistic missiles and therefore has limited effectiveness against selected threats. Patriot Advanced Capability-3 (PAC-3) has demonstrated the capability to engage tactical ballistic missiles in flight tests against more than 30 SRBM targets since 1999. One flight test was conducted against an MRBM target in 2002. Sixteen flight tests since 2000 featured multiple simultaneous Patriot engagements against two targets. During Operation Iraqi Freedom in 2003, Patriot intercepted all nine Iraqi SRBMs launched against it, but it also shot down two friendly aircraft due to a combination of training and system shortfalls. Patriot has implemented several enhancements and nine corrective actions to prevent future fratricide incidents.[5] Patriot did not meet its operational requirements for reliability, maintainability, or availability during the Post-Deployment Build (PDB)-7 Limited User Test (LUT) between May 2012 and January 2013. The Army plans to field the Patriot Radar Digital Processor (RDP) upgrade with PDB-8 in FY18. The RDP is expected to enhance reliability and reduce maintenance overhead for the Patriot radar. The LUT (FY12-13) also highlighted the growing complexity of the Patriot system, which requires a higher level of operator expertise and more intensive training. Due to the high demand for operational Patriot units in the field, the Army has dis-established its dedicated test unit for Patriot. Hence, as with THAAD, it is not possible to assess the capability of a well-trained Patriot unit in an operationally realistic scenario. Lack of training adds risk that during a conflict, Patriot units will not perform as expected. The Patriot system has not demonstrated that it can meet the requirements to survive certain electromagnetic environments, some of which were added after the Army designed and tested the Patriot system. Patriot does not meet certain Army Nuclear and Chemical Agency requirements. The Army granted a waiver for the deficient requirements with the support of the Army Nuclear and Chemical Agency.

Effective battle management is crucial for the success of the integrated BMDS, and C2BMC is the primary element intended to enable battle management at the system level. Spiral 6.4 (S6.4), comprised of the combatant command (COCOM) and Global Engagement Manager (GEM) suites, is the currently deployed version of C2BMC. C2BMC S6.4 has demonstrated the ability to provide situational awareness for the BMDS and to forward track data between various BMDS elements. With the addition of the GEM suite, C2BMC S6.4 added the capability to manage multiple AN/TPY-2 Forward-Based Radars (FBM).[6] Dual radar management by GEM was demonstrated during distributed ground testing in United States European Command in support of the European Phased Adaptive Approach Phase 1, distributed ground testing for cross-Combatant Command (CCMD) BMD operations in August 2014, and distributed ground testing in United States Pacific Command in support of the second TPY-2 (FBM) radar fielding to Japan in December 2014. Flight testing has yet to occur. C2BMC has

5 Detailed information regarding these corrective actions can be found in the 2002 Report to House Armed Services Committee Operation Iraqi Freedom (OIF) Patriot System Corrective Actions.

6 The GEM suite also provides improved track processing capabilities, but is limited to regional situational awareness only. The CCMD suite is the sole displayer of strategic GMD data for C2BMC.

not demonstrated real-time engagement direction capabilities. These capabilities are planned for future software builds.

Test Program Adequacy

The GMD test program was partially adequate to support assessment of the operational effectiveness, suitability, and survivability of the BMDS to defend the U.S. Homeland against IRBM and ICBM threats. FTG-06b (FY14) provided a limited demonstration of GBI intercept capability. Although FTG-06b (FY14) data will be useful for VV&A of M&S of future deployed GBIs in the FTG-06b (FY14) configuration, use of a more stringent screening process for the EKV batteries and new inertial measurement unit firmware and mounting hardware were not representative of the currently fielded GBIs; hence some data cannot be used for current VV&A. Further, FY/CY14 testing did not advance the VV&A of multiple other M&S that are needed for BMDS performance assessment because test failures precluded collection of flight test data needed for VV&A of IRBM and ICBM threat dynamics and signatures, multiple radar M&S, and atmospheric environments.

Flight testing of the Regional/Theater BMDS autonomous combat systems is sufficient to support a quantitative assessment of the systems' performance against SRBM and MRBM threats.[7] Flight testing is currently inadequate to provide quantitative assessments of effectiveness against IRBM threats.

Recommendations

The MDA should increase the development priority and associated funding for the BMDS simulation-based performance assessment capability including M&S VV&A and the ability to produce high-fidelity and statistically-significant BMDS-level performance assessments.

<u>Ground-based Midcourse Defense (GMD)</u>. To improve and demonstrate the reliability and availability of the operational GBIs, the MDA should:

- Systematically upgrade fielded EKVs until the planned Redesigned Kill Vehicle can be developed and fielded.
- Test a CE-I EKV-equipped GBI to accomplish the FTG-07 (FY13) test objectives.
- Extend the principles and recommendations contained in MDA's Independent Expert Panel assessment report on the GBI fleet to all components of the BMDS instantiation for Homeland Defense.

The MDA should conduct an intercept flight test of a CE-I EKV in the more stressing EKV fly-out environment to demonstrate CE-I EKV capability and to provide validation data for M&S of CE-I EKV performance.

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7 Regional/Theater autonomous combat systems are Aegis BMD, THAAD, and Patriot. Previous test results and data were documented in individual DOT&E Initial Operational Test and Evaluation technical reports.

The MDA should increase emphasis on GMD survivability testing, including cybersecurity. Tests, demonstrations, and exercises to acquire additional survivability data should be planned for inclusion in the BMDS IMTP.

Aegis Ballistic Missile Defense (BMD). The MDA should ensure that sufficient flight testing of the Aegis BMD 4.0 and Aegis Combat System (ACS) BL9.C1 systems is conducted to allow for VV&A of the M&S suites for those systems to cover the full design battlespace of threat ballistic missiles.

The MDA should conduct flight testing of the Aegis BMD 4.0 remote engagement capability against an upper-range threshold MRBM or IRBM target using an SM-3 Block IB Threat Upgrade guided missile. FTO-02 Event 2 is planned to demonstrate this capability (4QFY15).

The MDA should conduct operationally realistic testing that exercises the improved engagement coordination of Aegis BMD 4.0 with THAAD and Patriot. FTO-03 Event 2 is planned to demonstrate this capability (4QFY18).

The MDA should conduct sufficient ground and flight testing of the re-designed SM-3 Block IB TSRM nozzle after completion and installation of the new design concept to confirm the reliability of the new design under the most stressing operational flight conditions.

The MDA should conduct flight testing of the Aegis BMD ability to perform ship self-defense against anti-ship cruise missiles while engaging a raid of ballistic missile threats. Flight Test, Other-19 (FTX-19) is planned to partially demonstrate this capability using an ACS BL9C.1 ship conducting a simulated engagement using three live SRBM targets and two anti-air warfare target surrogates (2QFY15).

Terminal High-Altitude Area Defense (THAAD).[8] The Army should improve THAAD training to ensure that THAAD operators are prepared to use the system in combat.[9]

The MDA should rigorously test THAAD Configuration 2 given the large number of obsolescence redesigns of hardware and software. The MDA should flight test THAAD against a complex short-range target to invoke its advanced algorithms. FTO-02 Event 2 is planned to demonstrate both of these capabilities (4QFY15).

Data from Reliability Growth Test (FY15) should be assessed carefully in terms of both meeting reliability requirements and demonstrating reliability growth. Previous data indicate inconsistent reliability performance between test events.

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8 DOT&E concurs with the materiel release conditions levied upon the MDA and the Army to enable a full materiel release. Many of the concerns discussed in this report are being tracked and resolved through the materiel release process. The THAAD recommendations include only those unclassified recommendations not currently being addressed by the materiel release process, except where otherwise noted.

9 The resolution of training deficiencies is tracked by the materiel release process, and good progress has been made. Full resolution, however, is not scheduled until the end of FY17. Because of the magnitude of these problems, DOT&E will retain this as a recommendation until all of the resolution plans are proven feasible.

The MDA should flight test THAAD against an IRBM target. Flight Test, THAAD-18 (FTT-18) is planned to demonstrate this capability (4QFY15).

The MDA and the Army should implement equipment redesigns and modifications identified during natural environment testing to prevent problems seen in testing.

The MDA should demonstrate the use of approved THAAD documentation to verify accuracy and completeness of it.[10]

The MDA and the Army should conduct electronic warfare testing for THAAD.

Patriot. The Army should improve Patriot training to ensure that Patriot operators are prepared to use the system in combat. The Army should conduct a Patriot flight test against an anti-radiation missile target to validate M&S.

The MDA should include Patriot in system-level flight testing to demonstrate Patriot-to-THAAD automatic engagement coordination, Patriot-to-Aegis Combat System (ACS) manual or automatic engagement coordination, and the capability of Patriot to engage threats that are engaged but not intercepted by THAAD or ACS. FTO-03 Event 2 is planned to demonstrate this capability (4QFY18).

The Army should improve Patriot radar reliability.

The Army should reestablish a dedicated Patriot test battalion.

Command and Control, Battle Management, and Communications (C2BMC). The MDA should continue C2BMC development efforts to provide an engagement management capability to the BMDS.

The MDA should perform a flight test with multiple forward-based sensors to assess C2BMC's ability to correctly task and fuse track data from multiple sources observing multiple realistic targets.

The MDA should perform distributed ground tests in realistic threat environments for each CCMD to assess BMDS continuity of operations in the event of a C2BMC failure.

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[10] Implementing a process to ensure documentation is properly corrected when problems are found is tracked by the materiel release process, but ensuring that a final version of the documentation is acceptable is not. DOT&E will retain this recommendation until documentation errors found during testing are minimal.

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Section One
Introduction

This report is submitted in response to congressional reporting requirements as they pertain to the Ballistic Missile Defense System (BMDS). Congress initially specified these requirements in the fiscal year 2002 (FY02) National Defense Authorization Act (NDAA).[11] The FY09 NDAA expanded the scope of the reporting requirements.[12] These acts direct that the Director, Operational Test and Evaluation (DOT&E) each year characterize the operational effectiveness, suitability, and survivability of the BMDS and its elements. The acts also require DOT&E to assess the adequacy and sufficiency of the BMDS test program. Although the acts mandate an assessment of the BMDS and its test program for the preceding fiscal year only, this report considers test events for the preceding FY and calendar year (CY) in order for the report to be as current as possible.

This report also satisfies the FY15 NDAA direction that DOT&E provide Congress and the Secretary of Defense an assessment based on available test data of the sufficiency, adequacy, and results of missile defense system testing including whether each tested system will be sufficiently effective, suitable, and survivable when needed.[13] This report (including classified appendices) provides an assessment of how well the BMDS provides Homeland Defense and Regional/Theater Defense from the Combatant Command's point of view and an assessment of the performance of each missile defense system making up the BMDS.

The report is comprised of an unclassified report with four classified appendices. Both the unclassified report and the classified appendices adopt a parallel document structure. Section Two of the unclassified report describes the BMDS at both the system level and the component level; Section Three assesses operational effectiveness, operational suitability, and survivability; and Section Four assesses the adequacy of the BMDS test program. Appendices A through C provide classified information to supplement each of the above sections. Appendix D provides a summary of Ground-based Midcourse Defense (GMD) flight testing for FY09-14.

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[11] The FY02 NDAA was enacted as Public Law 107-107 dated December 28, 2001. Section 232 specifies that the DOT&E shall each year assess the adequacy and sufficiency of the BMDS test program over the preceding fiscal year.

[12] The FY09 NDAA was enacted as Public Law 110-417 dated October 14, 2008. Section 231 specifies that the DOT&E shall annually characterize the operational effectiveness, suitability, and survivability of the BMDS and its elements over the preceding fiscal year.

[13] The FY15 NDAA was enacted on December 16, 2014. Section 1662 (c) specifies that the DOT&E shall provide to the Secretary [of Defense] the assessment of the Director, based on the available test data, of the sufficiency, adequacy, and results of the testing of each covered [missile defense] system, including an assessment of whether the covered system will be sufficiently effective, suitable, and survivable when needed; and submit to the congressional defense committees a written summary of such assessment.

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Section Two
The Ballistic Missile Defense System (BMDS)

United States Northern Command (USNORTHCOM), United States Pacific Command (USPACOM), United States European Command (USEUCOM), and United States Central Command (USCENTCOM) employ the BMDS to defend U.S. territory, deployed forces, and allies against ballistic missiles of all ranges and in all phases of flight except initial boosting. United States Strategic Command (USSTRATCOM) synchronizes operational-level global missile defense planning and operations support. The specific manner in which the BMDS executes its mission is dependent on parameters such as which Combatant Command (CCMD) is conducting the missile defense operations, the specific missile defense mission and areas defended, the threat ballistic missile type, and the level of coordination necessary between U.S. missile defense activities and those of allied partners.[14,15,16,17]

Once these parameters have been determined, specific concepts of operations, operational plans, and an appropriate command structure can be defined, which are tailored to the CCMD. The concepts of operation depend on the types, numbers, and combinations of missile defense assets available to the CCMD. Combinations of missile defense assets can be used to achieve a specific mission with higher effectiveness, and a given combination of missile defense assets can contribute to multiple specific missions with varying levels of effectiveness. Figure 2-1 illustrates how numerous instantiations of the BMDS can be realized once all of these parameters have been set.

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14 The Missile Defense Agency (MDA) describes the ballistic missile defense (BMD) in terms of three phases of threat missile flight. Ascent is from launch through booster burnout to apogee, the highest point of flight above the Earth. Midcourse is flight above the Earth's atmosphere (exo-atmospheric, or above an altitude of approximately 100 kilometers) between apogee and re-entry into the Earth's atmosphere (endo-atmospheric). Lastly, Terminal is from re-entry into the Earth's atmosphere to impact.

15 The defense intelligence community classifies ballistic missile threats by range. Close-Range Ballistic Missiles (CRBMs) have ranges less than 300 kilometers; Short-Range Ballistic Missiles (SRBMs) have ranges from 300 to 1,000 kilometers; Medium-Range Ballistic Missiles (MRBMs) have ranges from 1,000 to 3,000 kilometers; Intermediate-Range Ballistic Missiles (IRBMs) have ranges 3,000 to 5,500 kilometers; and Intercontinental Ballistic Missiles (ICBMs) have ranges greater than 5,500 kilometers. CRBMs are treated as SRBMs in this report.

16 There are two basic missile types. One type is non-separating, in which the warhead payload (or re-entry vehicle) and the rocket body remain attached throughout the entire missile flight. The second type is separating, in which the re-entry vehicle separates from the missile body. Some separating missile threats employ a post-boost vehicle that separates from the rocket body and then reorients to fine-tune the re-entry vehicle trajectory before ejecting the re-entry vehicle. These missiles are referred to as complex-separating threats. If no post-boost vehicle is employed, then the missile is referred to as a simple-separating threat. CRBMs, SRBMs, and MRBMs can be either non-separating, simple-separating, or complex-separating missiles. All IRBMs and ICBMs are either simple- or complex-separating missiles.

17 "Defended area" refers to the area which the BMDS prevents missile threats from impacting. "Launch area denied" refers to the region from which the BMDS prevents missile threats from launching.

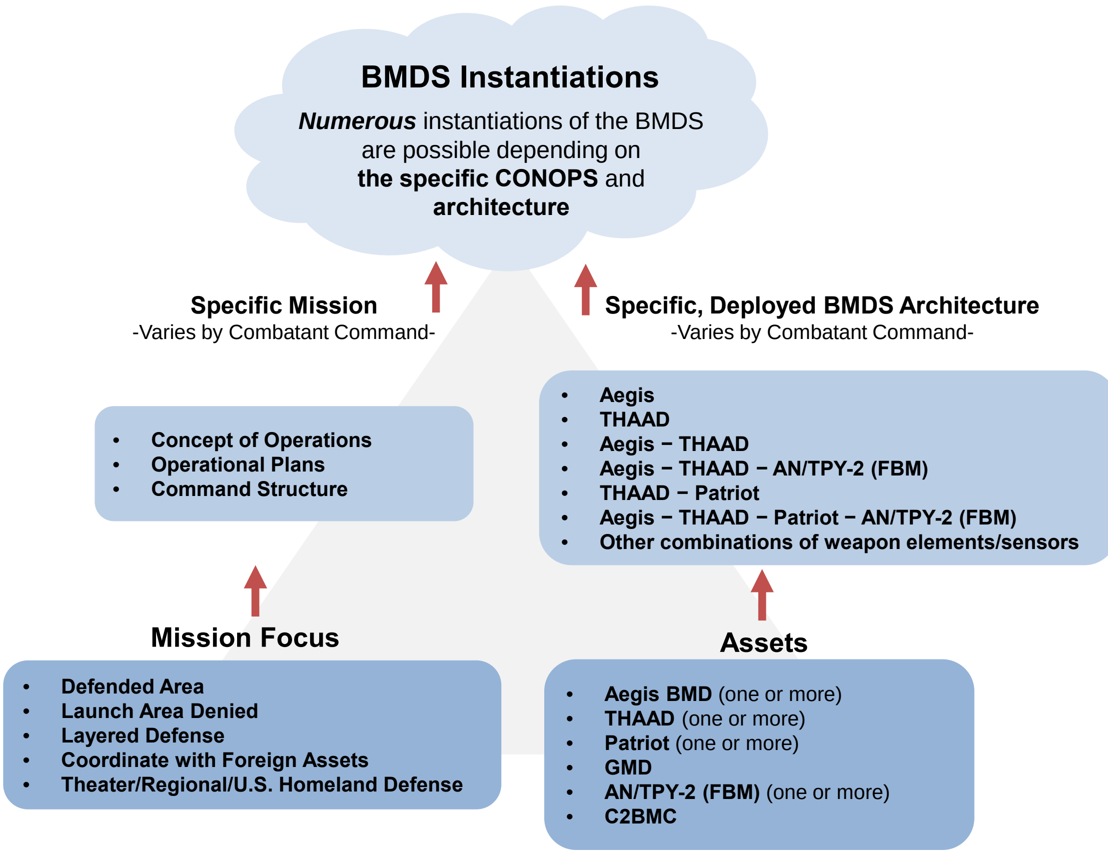


Figure 2-1. The Numerous Instantiations of the BMDS

System Description

To counter ballistic missile threats in all stages of their trajectories after initial boosting, the BMDS is intended to combine the capabilities of various combat systems with a sensor/command and control architecture to provide an integrated layered defense. Figure 2-2 shows the combat and sensor/command and control systems that compose the BMDS. The dashed boxes in Figure 2-2 denote future capabilities that are currently under development and are not currently integrated into the fiscal year/calendar year 2014 (FY/CY14) BMDS. Appendix A outlines details on future BMDS capabilities. The individual elements that currently compose the FY/CY14 BMDS are described in the next section.

As mentioned above, level of coordination on missile defense activities with allied partners is an important parameter in how the BMDS executes its mission. Figure 2-3 summarizes the contributions of allies to Regional/Theater BMD, and provides perspective on why this is an important parameter.

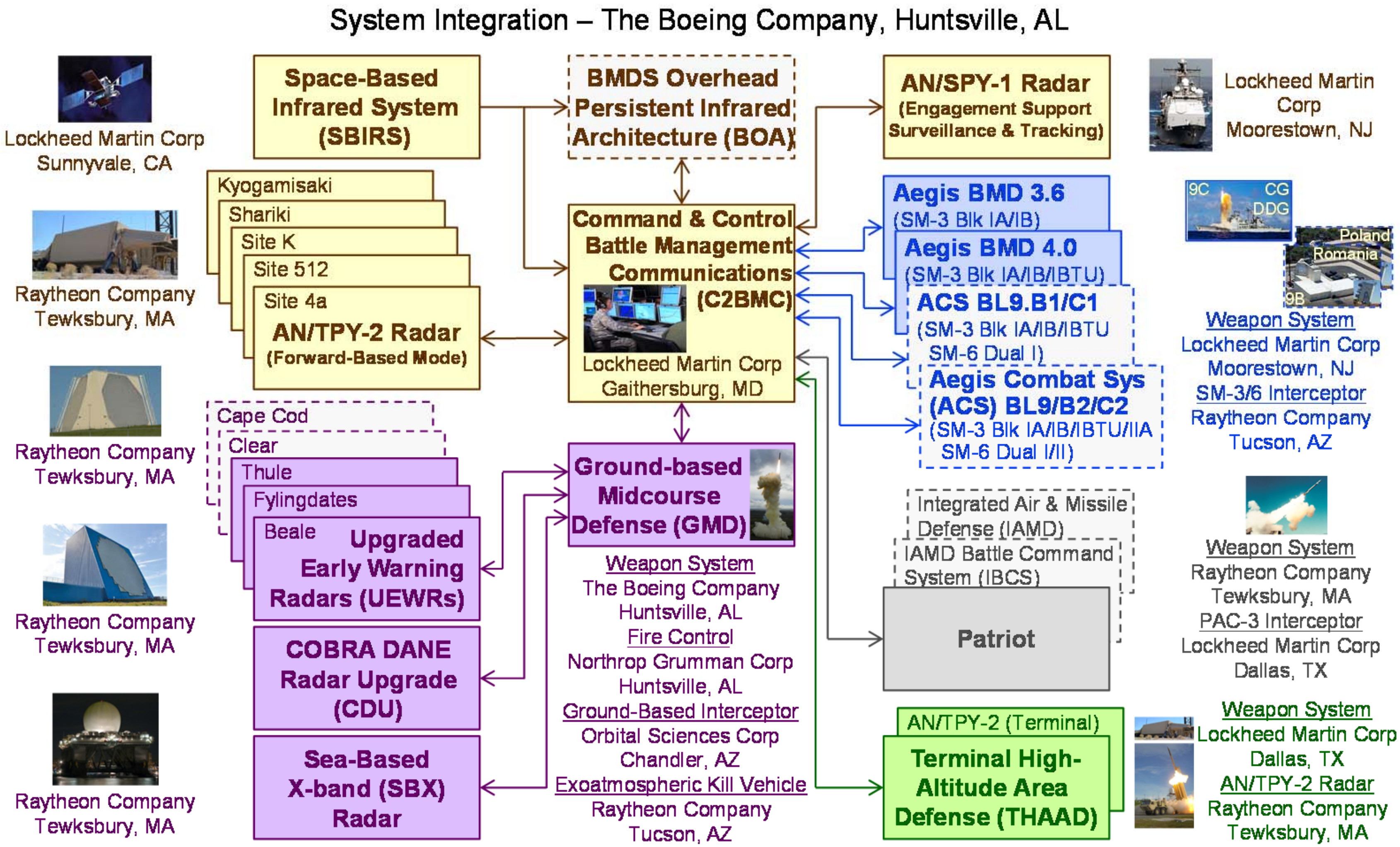
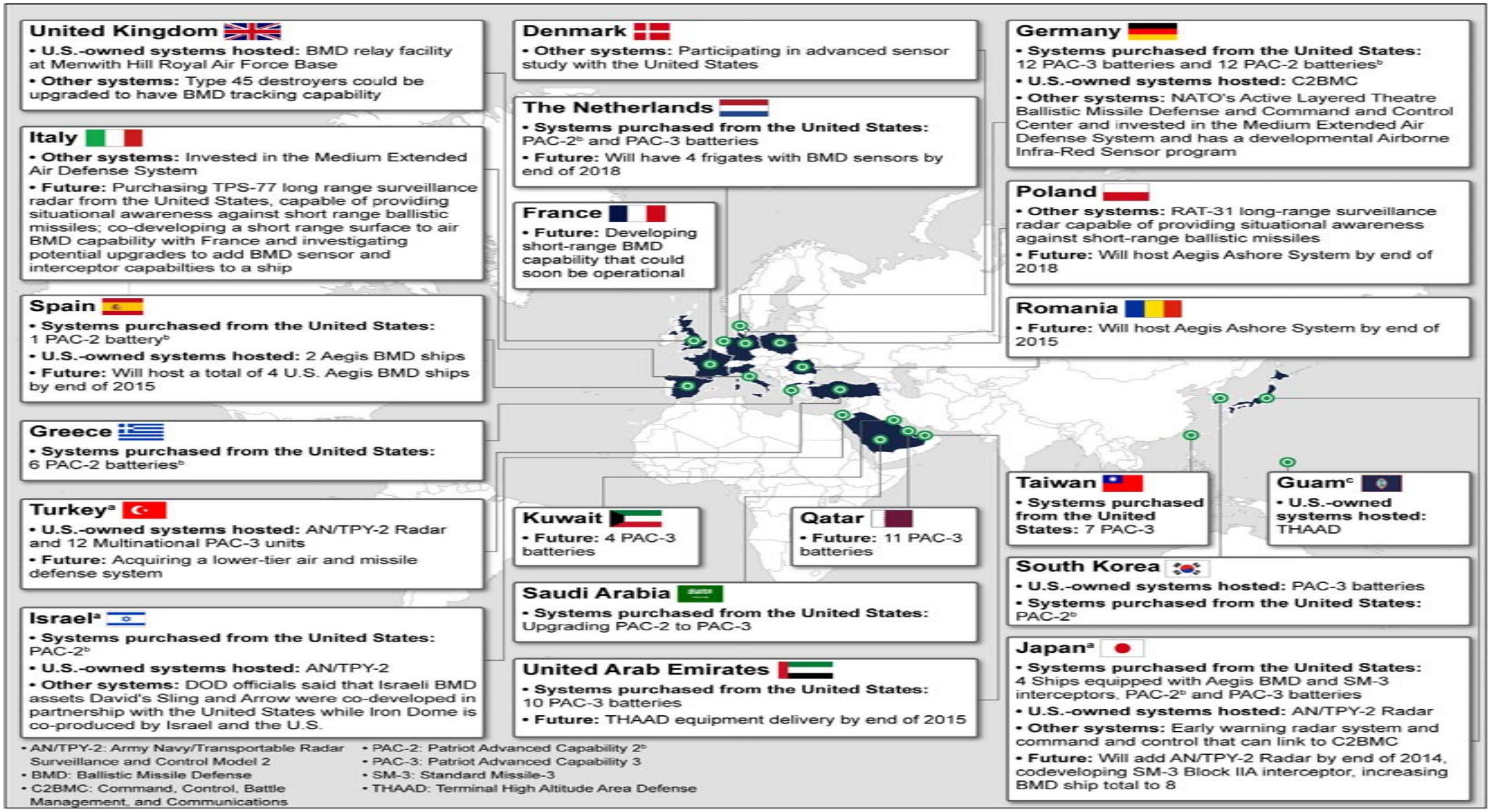


Figure 2-2. FY/CY14 Ballistic Missile Defense System



[a] Although 3 AN/TPY-2 radars are annotated, DoD has deployed 5 forward-based radars: Israel, Turkey, Japan (2 radars), and a 5th radar in the USCENTCOM area of operations.
[b] PAC-2 has limited ballistic missile defense capabilities.
[c] Guam is a territory of the United States, but is depicted here due to its role in regional BMD.

Figure 2-3. Summary of Allied Participation in Regional/Theater Missile Defense[18]

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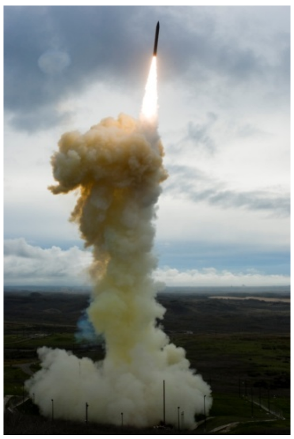
18 "Regional Missile Defense: DoD's 2014 Report Generally Addressed Required Reporting Elements, but Excluded Additional Key Details," Government Accountability Office, GAO-15-32 Appendix I, December 2014.

Element Descriptions

Autonomous Combat Systems

Combatant Commanders use the ground- and sea-based interceptor missiles of the BMDS combat systems for destroying threat ballistic missiles using either the force of a direct collision or an explosive blast fragmentation warhead.[19] Autonomous combat systems include the sensors dedicated to that system's fire control and interceptor missile's guidance system.

Ground-based Midcourse Defense (GMD)[20]



USNORTHCOM uses GMD to defend the U.S. Homeland against IRBM and ICBM attacks using the Ground-Based Interceptor (GBI) to defeat threat missiles during the midcourse segment of flight. GMD is operated by Soldiers of the 100th Missile Defense Brigade, Colorado Army National Guard, and the 49th Missile Defense Battalion, Alaska Army National Guard.

GMD consists of three-stage GBIs equipped with a Capability Enhancement-I (CE-I) Exo-atmospheric Kill Vehicle (EKV) or an upgraded EKV (CE-II) emplaced in silos at Fort Greely, Alaska, and Vandenberg Air Force Base (AFB), California. The GMD ground system includes GMD Fire Control nodes at Schriever AFB, Colorado, and Fort Greely, Alaska; Command Launch Equipment at Vandenberg AFB, California, and Fort Greely, Alaska; In-Flight Interceptor Communication System data terminals at Vandenberg AFB, California, Fort Greely, Alaska, and Eareckson Air Station, Alaska; and secure data and voice communication systems. GMD uses sensor data provided directly to it by radars dedicated to GMD, including Sea-Based X-band (SBX); non-dedicated radars including Aegis BMD, AN/TPY-2 Forward-Based Radars (FBM), Upgraded Early Warning Radars (UEWRs), and COBRA DANE Radar Upgrade (CDU); and the Space-Based Infrared System/Defense Support Program (SBIRS/DSP). Aegis BMD, AN/TPY-2 (FBM), and SBIRS/DSP sensor data are provided to GMD via the Command and Control, Battle Management, and Communications (C2BMC) element.

The Air Force operates the UEWRs, which are ultra-high frequency phased-array radars located at Beale AFB, California, and Thule Air Base, Greenland; each radar has two radar array faces that provide a 240-degree azimuth field of view. There is a third UEWR located at Fylingdales, United Kingdom, which has three radar array faces providing a 360-degree azimuth field of view. The radars are

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[19] Using the force of a direct collision to negate a threat ballistic missile is termed "hit-to-kill" technology.

[20] GMD provides the only BMDS system-level capability to defend the United States from ICBM threats. Hence, the GMD autonomous combat system is the Homeland Defense part of the BMDS.

used to detect, track, and classify ballistic missile threats targeting the United States. The radars perform both the BMD and legacy missile warning and space tracking missions.

The Air Force operates the CDU, which is an L-band phased-array radar with one radar array face that provides a 120-degree azimuth field of view, and is located at Eareckson Air Station (Shemya Island), Alaska. GMD uses the track data from the CDU as a principal data source to develop the GMD weapon task plan and in-flight target updates for GMD engagements.

The SBX radar is an X-band, single-face, phased-array radar located aboard a twin-hulled, semi-submersible, self-propelled ocean-going platform. The MDA employs the SBX radar as a test asset that can be operationally deployed as a midcourse sensor for the BMDS as required based on warning of an ICBM threat to the U.S. Homeland. The SBX radar performs high-resolution cued search, acquisition, track, and target discrimination.

Aegis Ballistic Missile Defense (BMD)

Using the Aegis BMD element, the Navy defends deployed forces and allies from SRBM, MRBM, and IRBM threats; provides forward-deployed radar capabilities by sending cues or target track data to other elements of the BMDS; and provides ballistic missile threat data to the C2BMC system for dissemination to CCMDs' headquarters to ensure situational awareness.

Aegis BMD is a sea-based missile defense system that employs the multi-mission Aegis Weapon System onboard Navy destroyers and cruisers with improved radar and missile capabilities. Aegis BMD capabilities include modifications to the AN/SPY-1 S-band phased-array radar for long-range surveillance and track of ballistic missiles; Standard Missile-3 (SM-3) Block IA and Block IB guided missiles, which use a maneuverable kinetic warhead to accomplish midcourse engagements of SRBMs, MRBMs, and IRBMs; modified SM-2 Block IV guided missiles, which provide terminal engagement capability against SRBMs; and a Vertical Launching System, which stores and fires SM-3 Block IA and Block IB and modified SM-2 Block IV guided missiles. The MDA transitioned an initial Aegis BMD capability to the Navy in October 2008. Thirty-three Aegis BMD ships are currently deployed. Twenty-three ships have an Aegis BMD 3.6 variant installed, seven ships have Aegis BMD 4.0.2 installed, and three ships have a development build of the Baseline 9.C1 system installed.

Aegis Ashore is a land-based version of Aegis BMD, with an AN/SPY-1 radar and Vertical Launching System to enable engagements against MRBMs and IRBMs with SM-3 guided missiles. In FY09, the President approved a European Phased, Adaptive Approach (EPAA) for missile defense of Europe using variants of the Aegis BMD in sea- and land-based modes with the SM-3 guided missile. In December 2011, the MDA issued a technical capability

declaration for Phase 1 of the EPAA architecture. Once Aegis Ashore is deployed in 2015, it will become the central, land-based component of the second phase of the EPAA for the defense of Europe.

Terminal High-Altitude Area Defense (THAAD)

Combatant Commanders will use THAAD to protect critical assets and forward-deployed forces by intercepting SRBMs, MRBMs, and IRBMs in the endo- or exo-atmosphere. THAAD consists of five major components: interceptors, launchers, an AN/TPY-2 X-band phased-array radar operating in its Terminal Mode (TM), THAAD Fire Control and Communications, and THAAD peculiar support equipment. THAAD is intended to complement the lower-tier Patriot element and the upper-tier Aegis BMD element by providing a system-level layered defense capability. THAAD can accept target cues for acquisition from the Aegis BMD (Engagement Support Surveillance and Tracking (ESS&T)), SBIRS/DSP, and other external theater sensors and command and control systems.

The Army issued a conditional materiel release for the first two THAAD batteries (THAAD Configuration 1) in February 2012. The first THAAD Configuration 1 battery was deployed to Guam in April 2013. An evolutionary upgrade (THAAD Configuration 2) is in testing, and additional batteries are planned to become available starting in 2015.

Patriot

Combatant Commanders use Patriot to defend deployed forces and critical assets from missile and aircraft attack and to defeat enemy surveillance air assets such as unmanned aerial vehicles in all weather conditions, and in natural and induced environments. The Patriot element includes C-band phased-array radars for detecting, tracking, classifying, identifying, and discriminating targets; battalion and battery battle management elements; Communications Relay Groups and Antenna Mast Groups for communicating between battery and battalion assets; launchers; and a mix of Patriot Advanced Capability-3 (PAC-3) hit-to-kill missiles, older blast fragmentation PAC-2 missiles, and PAC-2 Guidance Enhanced Missiles for negating missile and aircraft threats.

The MDA transitioned Patriot to the Army in 2002. Patriot continues to undergo evolutionary development upgrades and testing, with major system Post-Deployment Builds (PDBs) occurring approximately every three years. Patriot PDB-7 is currently in the field. The newest version of the Patriot missile is the PAC-3 Missile Segment Enhancement (MSE) interceptor, which provides increased battlespace compared to the PAC-3 missile. The Defense Acquisition Executive approved the PAC-3 MSE interceptor to enter Low-Rate Initial Production in FY14 and the interceptor is currently scheduled to be fielded with PDB-8 in 2017. The Army has approximately 50 Patriot batteries, some of which are deployed to countries in USCENTCOM, USEUCOM, and USPACOM.

Sensor/Command and Control Architecture

Combatant Commanders use the BMDS sensor/command and control architecture to detect, track, and classify threat ballistic missiles that target the United States and U.S. allies. The architecture also provides overall situational awareness and battle management, and directly supports the engagement of threat ballistic missiles by the BMDS combat systems.

Space-Based Infrared System (SBIRS)/Defense Support Program (DSP)

The Air Force operates the SBIRS/DSP, which is a satellite constellation of infrared sensors with an external interface to the BMDS located at Buckley AFB, Colorado. SBIRS/DSP provides the BMDS with the initial notification of a threat ballistic missile launch and the threatened defended area. The MDA declared a SBIRS/DSP active interface operational in February 2007, enabling C2BMC and the GMD fire control to receive early warning data directly from SBIRS/DSP.

AN/SPY-1 Engagement Support Surveillance and Tracking (ESS&T) Radar

The Navy operates the AN/SPY-1 S-band phased-array radar, which is deployed aboard 33 Aegis BMD-capable guided missile cruisers and destroyers of the Atlantic and Pacific fleets. The radar uses four radar array faces that provide 360-degree azimuth field of view. In addition to their fire control role in the conduct of Standard Missile engagements, the AN/SPY-1 radar can function as a mobile ESS&T radar for BMDS combat systems.

AN/TPY-2 Forward-Based Mode (FBM) Radar

The Army operates the transportable AN/TPY-2 X-band, single-face, phased-array radar. The radar provides forward-based acquisition and tracking of threat ballistic missiles of all ranges during their boosting, midcourse, and terminal phases of flight. The radar is controlled by the C2BMC to establish search plans, prioritize tasking, control processing, and distribute track data to other BMDS elements including coalition partners.

In 2006, the MDA deployed the first AN/TPY-2 (FBM) radar to Shariki, Japan. The MDA provided a second radar to Israel in 2008 followed by a third radar to Turkey in 2011. The radar deployed to Turkey is specifically allocated to the EPAA Phase 1 architecture. In 2012, the MDA deployed a fourth radar to the USCENTCOM area of responsibility. Lastly, in December 2014, the MDA installed a fifth radar at Kyogamisaki, Japan.

Command and Control, Battle Management, and Communications (C2BMC)

Combatant Commanders and other senior national leaders use the current C2BMC Spiral 6.4 (S6.4) for situational awareness on BMDS status, system coverage, and ballistic missile tracks by displaying selective data from

the BMDS Communications Network (BCN) for strategic/national and Regional/Theater missile defense. C2BMC also provides upper echelon deliberate planning at the CCMD and component level. BMDS elements (GMD, Aegis BMD, THAAD, and Patriot) use their own command and control battle management systems and mission planning tools for stand-alone engagements.

C2BMC S6.4 provides command and control for the AN/TPY-2 (FBM) radar. The S6.4 Global Engagement Manager (GEM) Suite provides updated sensor management, track processing, and reporting. Through the BCN, C2BMC forwards AN/TPY-2 (FBM) and AN/SPY-1 tracks to GMD. Additionally, through the Joint Tactical Information Distribution System and satellite communications, it forwards AN/TPY-2 (FBM) tracks for THAAD and Patriot cueing and Aegis BMD engagement support. C2BMC S8.2 is intended to improve and expand on S6.4 capabilities as the next step toward integrated sensor management and engagement coordination.

More than 70 C2BMC workstations are fielded at USSTRATCOM, USNORTHCOM, USEUCOM, USPACOM, and USCENTCOM; numerous Army Air and Missile Defense Commands; Air and Space Operations Centers; and other supporting warfighter organizations.

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Section Three
Assessment of Operational Effectiveness, Operational Suitability, and Survivability

This section of the report addresses the fiscal year 2002 (FY02) National Defense Authorization Act (NDAA) mandate, as amended, for the Director, Operational Test and Evaluation (DOT&E) to assess the operational effectiveness, operational suitability, and survivability of the Ballistic Missile Defense System (BMDS) and its elements. This report considers test events for the preceding FY and calendar year (CY) in order for the report to be as current as possible. Specific testing that occurred in FY/CY14 is first summarized followed by a discussion of the BMDS's operational effectiveness, operational suitability, and survivability.

Synopsis

During FY/CY14, the Missile Defense Agency (MDA) conducted eight flight tests and five ground tests. Data from a ninth flight test, Flight Test, Operational-01 (FTO-01, FY13), were also analyzed during the year.

The Ground-based Midcourse Defense (GMD) weapon element has not advanced Homeland Defense over the last five years. This is because the GMD program has spent the last five years correcting deficiencies uncovered during three failed intercept attempts beginning with Flight Test Ground-Based Interceptor (GBI)-06 (FTG-06) in December 2010. FTG-06b in June 2014 was the first successful GMD intercept since FTG-05 (FY09).

On the other hand, the Regional/Theater weapon elements have generally shown improvement over the last five years. Aegis Ballistic Missile Defense (BMD) 4.0 matured to become the newest deployed version of the Aegis Weapon System. The Terminal High-Altitude Area Defense (THAAD) Configuration 2 element, while not currently deployed, matured to the point that it was included in the first system-level operational test. Finally, Patriot matured its Post-Deployment Build-7 (PDB-7) software such that it replaced the PDB-6.5 software in the field.

Overall system-level assessment has been assessed as a limited Homeland Defense capability against Intermediate-Range Ballistic Missile (IRBM) or Intercontinental Ballistic Missile (ICBM) threats, and correspondingly, a partially integrated and layered combat capability against Regional/Theater Short-Range Ballistic Missile (SRBM) or Medium-Range Ballistic Missile (MRBM) threats. The primary impediments to increasing maturity are the lack of a fully-integrated and layered Regional/Theater combat capability against SRBMs and MRBMs, the lack of an automated engagement management capability, and the lack of operational flight testing of a limited Homeland Defense capability. The Integrated Master Test Plan (IMTP) has flight tests allocated to demonstrating all of these needed capabilities. FTO-02 and FTO-03, in 2015 and 2018 respectively, will contribute to the first demonstration of a fully-integrated, layered Regional/Theater combat capability. FTO-02 is a BMDS system-level operational test consisting of two events. Event 1 will provide critical data needed to assess Aegis Ashore's capability to defend Europe as part of the European Phased Adaptive Approach

(EPAA). An AN/TPY-2 radar in forward-based mode will provide the target track data that will enable Aegis Ashore to conduct a launch on remote engagement. Space-based sensors and command, control, battle management, and communications systems will also participate. Event 1 will be the first intercept test of Aegis Ashore and it will be conducted against an IRBM target. Event 2, which will also provide data critical to the assessment of the EPAA's ability to integrate the defense provided by Aegis Ashore with the defense capabilities of Aegis ships, will use a United States European Command (USEUCOM) scenario to test the Aegis BMD capability to engage an MRBM in the presence of post-intercept debris while simultaneously conducting anti-air warfare operations against a cruise missile surrogate. To create the debris scene for Aegis BMD, THAAD will engage a SRBM with its advanced radar algorithms and new Lot 4 interceptor. The Command and Control, Battle Management, and Communications Spiral 8.2 (C2BMC S8.2) is being designed to provide a limited engagement management capability and will be demonstrated during FTO-03. FTO-04 in 2020 will be the first dedicated operational test of U.S. Homeland missile defense capabilities.

FY/CY14 Flight and Ground Tests

During FY/CY14, the MDA conducted eight flight tests and five ground tests. Table 3-1 summarizes these flight tests. FTO-01 was included in Table 3-1 for reference since it was conducted just prior to the beginning of FY14 (September 2013). Table 3-2 summarizes FY/CY14 ground testing. These flight and ground tests were in accordance with the MDA-generated and DOT&E-approved IMTPs.[21]

The MDA conducted one Homeland Defense flight test during FY/CY14. FTG-06b (FY14) was a developmental flight test demonstrating the first successful Capability Enhancement-II (CE-II) Exo-atmospheric Kill Vehicle (EKV) intercept of an IRBM target. This mission demonstrated technical fixes the MDA made to the CE-II EKV following two CE-II failures (FTG-06, FY10 and FTG-06a, FY11) and one CE-I EKV failure (FTG-07, FY13). Conversely, the MDA conducted no Regional/Theater system-level flight testing during FY/CY14. Since FTO-01 (FY13) had just been conducted, the MDA activities focused on data analysis from FTO-01 (FY13) and preparation for its next flight test, FTO-02, which is scheduled for June (Event 1) and September (Event 2) 2015.

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21 IMTP version 13.1 dated March 4, 2013; version 14.1 dated March 31, 2014; and version 14.2 dated September 22, 2014.

Table 3-1. Summary of FY/CY14 Flight Tests

BMDS Homeland Defense/GMD	**FTG-06b (June 22, 2014) GFC 6B1.7, Aegis BMD 3.6.1 (LRS&T), SBX 2.3.2, C2BMC S6.4 MR2**		
	Test Description. FTG-06b was a medium interceptor time-of-flight, medium closing velocity engagement of an IRBM target by a GBI equipped with a CE-II EKV. The MDA launched the target from the U.S. Army Reagan Test Site at the Kwajalein Atoll in the Republic of the Marshall Islands. The target boost vehicle flew out to its designated aim point and then deployed an ICBM-like reentry vehicle (surrogate warhead). The Aegis BMD and SBX radars provided the GMD Fire Control (GFC) with threat tracks. The C2BMC participated in this test. The GBI was launched from Vandenberg AFB.	Outcome. INTERCEPT. The MDA launched the IRBM target. The Aegis BMD and SBX radars acquired and tracked the target and sent track reports to the GFC site at Schriever AFB. The GFC correlated the tracks from the radars. Army warfighters from the 100th Missile Brigade executed the engagement from the GFC consoles and launched a GBI from Vandenberg AFB. The C2BMC received data from the GFC and forwarded that data to C2BMC nodes at USPACOM, USNORTHCOM, and USSTRATCOM for situational awareness. The GBI boost vehicle flew out to its designated aim point and deployed its CE-II EKV. The EKV intercepted the target reentry vehicle.	Test Adequacy Issues. Intercept flight test FTG-06b provided a limited demonstration of GBI capability, but aspects of that test were developmental in nature and limited the scope of capability demonstration. In addition, although FTG-06b data will be useful for validation of M&S of future deployed GBIs that are in the FTG-06b configuration, specific aspects of the test GBI's EKV were not representative of the currently fielded GBIs.
BMDS Regional/Theater	**FTO-01 (September 10, 2013) Aegis BMD 3.6.2e (SM-3 Block IA), THAAD 2.0.1, AN/TPY-2 (FBM) CX-1.2.3, C2BMC S6.4 MR2**		
	Test Description. FTO-01 was the first BMDS Regional/Theater system-level operational flight test with multiple firing elements (Aegis BMD and THAAD). They engaged a near-simultaneous raid of two threat-representative MRBMs using a layered architecture that included C2BMC and an AN/TPY-2 (FBM) radar. The missile defense command structure also included an Upper Tier Coordination Officer (UTCO) and Air Defense Artillery Fire Control Officer (ADAFCO).	Outcome. TWO INTERCEPTS. MRBM 1 was engaged in a layered defense with an Aegis BMD 3.6.2e destroyer as the first shooter and THAAD as the second shooter. The interceptor fired from the Aegis BMD destroyer successfully intercepted MRBM 1. As part of the layered defense, THAAD launched an interceptor at the target destroyed by Aegis as a contingency in the event the SM-3 did not achieve an intercept. THAAD also launched an interceptor against MRBM 2, which was also successfully intercepted.	Test Adequacy Issues. Patriot did not participate as previously planned. The flight test campaign was reduced in scope from three live fire events to one because of target missile availability. System integration and interoperability was reduced because of issues with the communication networks during the live fire event.

Table 3-1 (Continued). Summary of FY/CY14 Flight Tests

Aegis BMD	**FTM-22 (October 3, 2013) Aegis BMD 4.0.2 (SM-3 Block IB)**		
	Test Description. The FTM-22 flight mission called for an Aegis BMD 4.0.2 cruiser to organically intercept a separating MRBM target with an SM-3 Block IB guided missile. The flight test was the second of two Initial Operational Test and Evaluation (IOT&E) flight tests for the Aegis BMD 4.0 system and SM-3 Block IB missile.	Outcome. INTERCEPT. The ship detected, tracked, engaged, and intercepted the MRBM target with an SM-3 Block IB missile. The FTM-22 engagement was the fifth successful intercept mission conducted with the Aegis BMD 4.0 system with an SM-3 Block IB guided missile, and the first intercept of an MRBM target with that system and missile; FTM-20 intercepted a lower-range threshold unitary MRBM with an SM-3 Block IA missile.	
	SCDPTV-01 (October 24, 2013) SM-3 Block IIA (Interceptor-only)		
	Test Description. SCDPTV-01 was a live firing test of the SM-3 Block IIA's MK 72 MOD 2 booster with inert 21-inch-diameter mass equivalent upper-stage assembly in the missile's MK 29 MOD 0 lightweight canister.	Outcome. SUCCESSFULLY LAUNCHED. The booster and mock upper stage was successfully launched from the Aegis Vertical Launching System. The test was a follow-on event from a restrained ground firing in FY13, and the first flight test to validate missile and canister designs.	
	FTX-18 (January 15, 2014) Aegis BMD 4.0.2 (Simulated SM-3 Block IB)		
	Test Description. The mission called for an Aegis BMD 4.0.2 destroyer to detect, track, and conduct simulated SM-3 Block IB engagements against three short-range ballistic missiles in a raid scenario. FTX-18 was the last of the three IOT&E test missions.	Outcome. THREE SIMULATED INTERCEPTS. The ship detected, tracked, and engaged the three targets with SM-3 Block IB simulated dynamic missiles. FTX-18 is the only live-target raid engagement conducted with the Aegis BMD 4.0.2 system, but the engagements were simulated.	

Table 3-1 (Continued). Summary of FY/CY14 Flight Tests

Aegis BMD (Continued)	**FTX-20 (October 17, 2014) Aegis Combat System (ACS) BL9.C1**		
	Test Description. FTX-20 was a developmental test tracking exercise wherein an Aegis ship with ACS BL9.C1 software intended to detect and track a separating MRBM target.	Outcome. TRACKED. The ship detected and tracked the MRBM target. Several fire control, discrimination, and engagement functions were exercised, but no simulated guided missiles were launched (by design).	
	FTM-25 (November 6, 2014) ACS BL9.C1 (SM-3 Block IB, SM-2 Block IIIA)		
	Test Description. The FTM-25 flight mission called for an ACS BL9.C1 destroyer to organically intercept a simple-separating SRBM target with an SM-3 Block IB guided missile, while simultaneously intercepting two low-flying cruise missiles with SM-2 Block IIIA guided missiles. The flight test was the first test mission with the ACS BL9.C1 system.	Outcome. THREE INTERCEPTS. The ship detected, tracked, engaged, and intercepted the SRBM target with an SM-3 Block IB missile. The two cruise missiles were engaged near-simultaneously with SM-2 missiles, and both were intercepted. The FTM-25 engagement was the first live-fire event of the ACS in Integrated Air and Missile Defense (IAMD) radar priority mode.	Test Adequacy Issues. The ballistic missile target in FTM-25 was engaged with an SM-3 Block IB missile. Originally, there were two planned ballistic missile intercepts, but target and target launcher failures prevented the second SRBM engagement; this prevented testing of the system's IAMD functionality to the degree desired.
Aegis Ashore	**AA CTV-01 (May 21, 2014) ACS BL9.B1 (Simulated SM-3 Block IB)**		
	Test Description. AA CTV-01 was an interceptor-only flight test mission designed to test the ability of the Aegis Ashore Missile Defense Test Complex (AAMDTC) with ACS BL9.B1 software at the Pacific Missile Range Facility to fire, control, establish uplink/downlink communication, provide guidance commands, and provide target information to an SM-3 Block IB guided missile.	Outcome. SIMULATED INTERCEPT. The Aegis Ashore test facility acquired, tracked and engaged a simulated ballistic missile target, and fired an SM-3 Block IB missile from the Vertical Launching System. Several fire control and engagement functions were exercised during the test. AA CTV-01 was the first live fire event with ACS BL9B.1 and the first SM-3 firing from the AAMDTC.	Test Adequacy Issues. The Aegis Vertical Launching System is tilted due to range safety concerns. This is not operationally representative of the to-be fielded configuration.

Table 3-1 (Continued). Summary of FY/CY14 Flight Tests

	Patriot/MEADS FT-2 (November 6, 2013) MEADS (PAC-3 MSE)		
Patriot/MEADS	Test Description. MEADS FT-2 was the second MEADS intercept flight demonstration and the last before the U.S. completed the Design and Development Phase and U.S. commitment to the program. In FT-2, MEADS engaged two near simultaneous targets from opposite directions, a QF-4 full-scale aircraft target approached from the south while a Lance tactical ballistic missile target attacked from the north. MEADS launched one PAC-3 MSE interceptor at the QF-4 and two at the Lance.	Outcome. TWO INTERCEPTS. MEADS demonstrated the capability to detect, track, engage, intercept, and kill both a tactical ballistic missile target and a full-scale aircraft target with MSE interceptors. The first MSE missile in the ripple method of fire intercepted and killed the Lance at the planned altitude and range. The second MSE missile performed nominally throughout its flight and properly self-destructed after the first MSE intercepted the target. The third MSE missile intercepted and killed the QF-4 at the planned altitude and range.	Comment. Some test data were relevant to Patriot because the test used PAC-3 MSE interceptors.

Table 3-2. Summary of FY/CY14 Ground Tests

	GTI-04e Part 1a Phase I (April 2013) and Phase II (October 2013) Aegis BMD 3.6.1/4.0.2, THAAD 2.1, Patriot PDB-6.5, AN/TPY-2 (FBM) CX-1.2.3, C2BMC S6.4 MR2		
BMDS	Test Description. GTI-04e Part 1a was a two-phase hardware-in-the-loop (HWIL) ground test that assessed BMDS interoperability and suitability in a Regional/Theater event for USEUCOM and USCENTCOM. Phase I was an operational test which assessed the new mission functionality of the BMDS operational configuration and supported AN/TPY-2 (FBM) radar, C2BMC, and THAAD materiel releases. Phase II was a developmental test that collected data on the new debris mitigation functionality of the AN-TPY-2 (FBM) radar.	Outcome. Phase I provided data for Regional/Theater assessments of the functional BMDS architecture in USEUCOM and USCENTCOM defending against operationally representative threats. Data were collected using new materiel releases for the AN/TPY-2 (FBM) radar, THAAD, and C2BMC. In Phase II, debris mitigation capabilities were demonstrated by the AN/TPY-2 (FBM) radar.	Test Adequacy Issues. In Phase I, endgame analyses were not conducted for Aegis BMD. Issues identified with debris modeling resulted in a delay in data collection on debris mitigation, which became Phase II. In Phase II, comprehensive assessment of the debris mitigation functionality was restricted by limited data. In addition, GTI events are not accredited for performance assessment purposes.

Table 3-2 (Continued). Summary of FY/CY14 Ground Tests

	GTI-04e Part 2 (May 2014) **Aegis BMD 3.6.1/3.6.3/4.0.2, THAAD 2.2, GFC 6B2.2.1, AN/TPY-2 (FBM) CX-1.2.3, SBX 3.2.0, C2BMC S6.4 MR2**		
BMDS	Test Description. GTI-04e Part 2 was the first operational test of the BMDS in a HWIL venue for USPACOM and USNORTHCOM Regional/Theater and Homeland Defense scenarios involving SRBMs, MRBMs, IRBMs, and ICBMs. The event assessed new software builds for GFC, SBX, and Aegis BMD. Data from the event were used to assess the fielding decision of the Kyogamisaki AN/TPY-2 (FBM) radar in addition to testing new functionalities for the AN/TPY-2 (FBM) PACOM radars (boost phase cueing and new focused search plans) and for Aegis BMD (SM-3 Block 1B).	Outcome. Redundant coverage was demonstrated by the dual AN/TPY-2 (FBM) capability. C2BMC provided situational awareness and demonstrated interoperability with Regional/Theater BMDS elements and demonstrated boost phase cue capabilities managing two AN/TPY-2 radars. Aegis BMD 3.6.3 demonstrated multiple capability upgrades including increased engagements capacity, increased launch point/impact point table limit, J10.2 message corrections supporting THAAD post-intercept debris mitigation algorithms, and combined launch area denied/defended area doctrine. THAAD demonstrated defense of Guam. GFC 6B2.2.1 and SBX 3.2.0 demonstrated tasking performance improvements and Command Launch Equipment (CLE) 4.3.4 was exercised for the first time. Patriot PDB 7.0 showed interoperability improvements.	Test Adequacy Issues. The effectiveness of the boost phase cues was limited by the AN/TPY-2 (FBM) operational mission profile and the sensor resource management configuration settings. The AN/TPY-2 (FBM) experienced threat acquisition problems while testing focused search plans commanded by C2BMC. Multiple M&S were not accredited for performance assessments.
	Fast Fire (May 5, 2014) **Aegis BMD 4.0.2, AN/TPY-2 (FBM) CX-1.2.3, C2BMC S6.4 MR2**		
Fast Events	Test Description. Fast Fire, which was conducted as part of GTI-04e Part 2 (FY14), tested the ability of Aegis BMD 4.0.2 to support its designed-to maximum number of simultaneous ballistic missile and anti-air warfare engagements and control all standard missiles in those engagements. AN/TPY-2 (FBM) provided forward-based radar data to support the engagements.	Outcome. The designed-to maximum number of simultaneous ballistic missile and anti-air warfare engagements was successfully exercised in HWIL runs.	

Table 3-2 (Continued). Summary of FY/CY14 Ground Tests

Fast Events	**Fast Phoenix (December 2013)** **Aegis BMD 3.6.1/3.6.3, THAAD 2.0, GFC 6B1.6, AN/TPY-2 (FBM) CX-1.2.2, C2BMC S6.4 MR2**		
	Test Description. Fast Phoenix used both operational and HWIL assets (C2BMC, AN/TPY-2(FBM), Aegis BMD, GFC, THAAD, Patriot, and SBIRS) to gather data in support of a performance assessment of a new BMDS communications architecture in USPACOM. The event also tested representative USEUCOM and USCENTCOM architecture configurations using USPACOM architecture and communications along with HWIL and simulated assets.	Outcome. Fast Phoenix demonstrated network integration for the new LMMT and showed that the LMMT did not negatively impact BMDS message traffic when configured correctly. The event identified causes of message losses within the BMDS communications throughput and other interoperability issues. Fast Phoenix was the first ground test where PDB 7.0. Patriot, as well as Aegis BMD and THAAD, tracked and engaged regional threats. The GFC processed AN/TPY-2 (FBM) radar and Aegis BMD ESS&T tracks via C2BMC. Data on BMDS network message flow were gathered successfully for both USEUCOM and USCENTCOM architectures.	
	Fast Exchange HWIL (June 2014) and Distributed (August 2014) **Aegis BMD 3.6.1/3.6.3/4.0.2, THAAD 2.2, AN/TPY-2 (FBM) CX-1.2.3, C2BMC S6.4 MR2**		
	Test Description. Fast Exchange was a two-part event conducted to evaluate the capabilities and limitations of sensor data sharing in a cross-area of responsibility (AOR) environment for USEUCOM and USCENTCOM. It was the first ground test to include Soldiers operating an AN/TPY-2 (FBM) radar.	Outcome. The passing of geographically filtered sensor track data between BMDS elements was demonstrated in a cross-AOR environment.	Test Adequacy Issues. AN/TPY-2 (FBM) acquisition results in the event may not have varied as much from run to run as would be expected operationally because of modeling deficiencies. Multiple M&S were not accredited for performance assessment.

The MDA also executed five Aegis BMD autonomous combat system flight tests, one Aegis Ashore flight test, and one Patriot/Medium Extended Air Defense System (MEADS) flight demonstration. Aegis BMD Flight Test, Standard Missile (SM)-22 (FTM-22, FY14), FTM-25 (FY15), and Patriot/MEADS Flight Test-2 (FT-2, FY14), which used Patriot Advanced Capability-3 (PAC-3) Missile Segment Enhancement (MSE) missiles, were intercept tests. Aegis BMD Flight Test, Other-18 (FTX-18, FY14) engaged live ballistic missile targets with simulated SMs, and FTX-20 (FY14) was a target missile tracking exercise. Hence, only the target missiles flew on these two latter missions. Finally, Aegis Ashore Controlled Test Vehicle-01 (AA CTV-01, FY14) and Aegis BMD SM-3 Cooperative Development Propulsion Test Vehicle-01 (SCDPTV-01, FY14) were interceptor-only flight tests.

The MDA completed five system-level ground tests in FY/CY-14. Ground Test, Integrated-04e (GTI-04e, FY14) focused on system interoperability and suitability for Combatant Command (CCMD) BMD. Part 1a, Phase 2 applied to USEUCOM and United States Central Command (USCENTCOM) while GTI-04e Part 2 (FY14) applied to United States Pacific Command (USPACOM) and United States Northern Command (USNORTHCOM). GTI-04e Part 2 (FY14) and the Fast Fire event (FY14) explored the ability of Aegis BMD 4.0.2 to support its "designed-to" maximum number of simultaneous ballistic missiles and anti-air warfare engagements. The Fast Phoenix event (FY14) ground tested a new communications architecture using the Link Monitoring Management Tool (LMMT) between Aegis BMD ships and the C2BMC element. Fast Exchange (FY14) examined cross CCMD sensor data sharing specifically for USEUCOM and USCENTCOM.

Assessment by Autonomous Combat System

The autonomous combat systems have undergone significantly more testing than the integrated BMDS. Aegis BMD, Patriot, and THAAD have each undergone dedicated operational testing; GMD has not. This section provides a summary of operational effectiveness, operational suitability, and survivability for each autonomous combat system, based on the results of all testing to date. Appendix B provides additional supporting analysis for these summaries.

Ground-based Midcourse Defense (GMD)

GMD has demonstrated a partial capability to defend the U.S. Homeland against small numbers of simple ballistic missile threats launched from North Korea and Iran, but a quantitative assessment of the operational effectiveness is currently not possible. A quantitative assessment will require additional flight testing and extensive ground testing that is supported by modeling and simulations (M&S) accredited for performance assessment. GMD M&S and required ancillary M&S currently lack such accreditation.

<u>Operational Effectiveness</u>. Table 3-3 provides a summary of GMD intercept flight tests since 2006. The first three intercept flight tests demonstrated a capability of the GMD system and GBIs equipped with the CE-I EKV to intercept targets in engagements with relatively short GBI fly outs and relatively low closing velocities. The seventh test, FTG-06b (FY14), demonstrated a capability of the GMD system and GBIs equipped with the CE-II EKV to

intercept targets in engagements with somewhat longer GBI fly outs and medium closing velocities. In all of these tests, the MDA used an IRBM-class target boost vehicle that deployed an ICBM-like reentry vehicle (surrogate threat warhead).

Table 3-3. GMD Intercept Flight Test Summary

Intercept Flight Test	Date	Closing Velocity		EKV Version		Hit
		Low	Medium	CE-I	CE-II	
FTG-02	September 1, 2006	X		X		Yes
FTG-03a	September 28, 2007	X		X		Yes
FTG-05	December 5, 2008	X		X		Yes
FTG-06	January 31, 2010		X		X	No
FTG-06a	December 15, 2010		X		X	No
FTG-07	July 5, 2013		X	X		No
FTG-06b	June 22, 2014		X		X	Yes

In three of the intercept flights, the EKV failed to intercept the target RV. After each failure, the MDA convened a Failure Review Board to determine the root cause. A brief description of the identified root cause of each failure is presented in Table 3-4. Three flight test failures during the past five years have raised questions regarding the robustness of the EKV's design, which led to a DOT&E FY13 Annual Report recommendation to employ a rigorous systems engineering process to assure the redesigned EKV is robust against potential failures. During FY/CY14, the MDA developed and fully tested EKV software for CE-I GBIs, which included a capability to reset and recover the flight computer following a voltage shift. This software is now fielded to all deployed CE-I EKVs. Further, the MDA is developing new battery and ground ties, and once tested, plan to incorporate them into the CE-II Block 1 deliveries beginning in FY16. Additionally, the MDA initiated a Redesigned Kill Vehicle (RKV) effort.

The FTG-07 (FY13) flight test failure raised questions about the effectiveness and reliability of the CE-I EKV in the more stressing EKV fly out environment entailed in the FTG-06 (FY10), FTG-06a (FY11), FTG-07 (FY13), and FTG-06b (FY14) intercept flight test scenario. In that more stressing flight test scenario, the CE-I EKV has only been tested once, and in that test, the EKV failed to deploy and failed to intercept. Since substantial differences in the inertial measurement unit (IMU) hardware, software, and IMU mounting exist between the fielded CE-I EKVs and the CE-II EKV that was tested in FTG-06b (FY14), an intercept flight test of a CE-I EKV in the more stressing EKV fly out environment is needed to demonstrate CE-I EKV capability. The MDA is planning to conduct a flight test of a CE-I EKV-equipped GBI in FY17 as part of the FTG-11 Salvo Test.

Table 3-4. GMD Intercept Flight Test Failure Root Causes

Intercept Flight Test Failures	Root Cause
FTG-06 (FY10)	Improper installation during fabrication of a critical component of the CE-II EKV that resulted in an inflight failure of one of the EKV divert thrusters.
FTG-06a (FY11)	Inadequate performance of the inertial measurement unit (IMU) within the CE-II EKV in the presence of high frequency vibrations that were caused by the EKV divert thrusters.[a]
FTG-07 (FY13)	An EKV battery failure coupled with a vulnerability in the EKV grounding system prevented the CE-I EKV separation from the last stage of the GBI boost vehicle.[b]

[a] This component has subsequently been redesigned and its performance demonstrated in FTG-06b (FY14).

[b] The MDA applied a more stringent screening process to the EKV batteries prior to FTG-06b (FY14) – the EKV batteries performed adequately in that test.

Operational Suitability. The MDA has demonstrated a "Limited" characterization of BMDS suitability for the defense of the U.S. Homeland. Based on the data acquired in intercept flight tests and GMD participation in system-level ground tests, the GMD is interoperable with the BMDS radars, the Aegis BMD, and C2BMC. Also, the GMD fire control is interoperable with the GBI missile fields. Interoperability of the GMD Communications Network has been demonstrated.

The reliability and availability of the operational GBIs is low, and the MDA continues discovering new failure modes during testing. The possibility of random process failures in the manufacture of GBIs was highlighted by the intercept flight test failure in FY10. GMD has demonstrated partial maintainability. The MDA has delivered and fielded operational GBIs concurrent with flight testing. GBI configuration changes based on flight test discovery have occurred incrementally, so that fielded GBIs do not all have the same hardware configuration. The MDA should systematically upgrade fielded EKVs with these upgrades until the RKV can be developed and fielded.

The MDA has continued its GBI refurbishment effort and plans to upgrade and standardize the fielded GBIs over a period of years. Concurrently, the MDA has resourced a limited stockpile reliability program to improve overall GBI booster and EKV reliability and produceability. These efforts are important to improve the reliability of GMD.

Survivability. The MDA has demonstrated a "Limited" characterization of BMDS survivability for the defense of the U.S. Homeland. GMD demonstrations of survivability have been limited. The survivability characterization is based primarily on facility testing and component-level testing and suffers from significant data gaps that are identified in the BMDS IMTP. Survivability data on many GMD components and supporting BMDS assets in chemical, nuclear, and biological environments are limited.

Aegis Ballistic Missile Defense (BMD)

The element-level assessment of Aegis BMD performance is made for the Aegis BMD 4.0 system with SM-3 Block IB guided missiles, which completed IOT&E in FY14. The BMD 3.6 system with SM-3 Block IA missiles, which was last flight tested in FY13, was characterized in last year's assessment of the BMDS. Aspects of the Aegis BMD 3.6 performance characterization will be discussed here, when they are applicable to the assessment of Aegis BMD 4.0 capabilities. ACS BL9 is not assessed or characterized in this report since there has been only a single intercept flight test of that system and no high-fidelity M&S analyses have been performed with accredited models.[22]

Testing has demonstrated that the Aegis BMD 4.0 system possesses a capability to engage non-separating and complex-separating SRBM threats, simple-separating MRBM, and lower-range threshold IRBM threats in the midcourse phase of flight using SM-3 Block IB guided missiles. However, flight testing and M&S did not test the full range of expected engagement geometries, threat types, threat ground ranges, and threat raid sizes.

- The assessment of Aegis BMD 4.0 SRBM engagement capability is based primarily on results from two flight tests against complex-separating targets and on results from one flight test against a non-separating ballistic missile. Results from five simulated engagements against SRBMs and other applicable flight test, ground test, and M&S data are all considered, as appropriate.
- The assessment of the system's MRBM engagement capability is based primarily on results from four flight tests against MRBM or MRBM-like targets.[23] Results from seven simulated engagements against MRBM-like targets, M&S results, and other applicable flight and ground test data are all considered, when applicable.
- The assessment of IRBM engagement capability is based on a single remote engagement against a separating lower-range threshold MRBM, legacy Aegis BMD 3.6.1 flight test data from the FTM-15 (FY11) flight mission, M&S, and HWIL exercises.
- A maintenance demonstration and other in-port and at-sea opportunities to collect data on reliability, maintainability, availability, and other suitability measures were used.
- Lastly, a series of multi-warfare exercises to explore ship self-defense capabilities and retention of other legacy mission capabilities while conducting BMD missions were included.

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22 It is worth noting that recent testing with ACS BL9 systems has demonstrated that Aegis Ashore (BL9.B1) can fire, detect, and control an SM-3 Block IB guided missile, and BL9.C1 destroyers have the capability to intercept a simple-separating SRBM with an SM-3 Block IB missile while simultaneously defending against two anti-ship cruise missiles with SM-2 Block IIIA missiles.

23 "MRBM-like" targets were SRBM targets in terms of range, but with MRBM characteristics.

Operational Effectiveness. Table 3-5 provides a summary of Aegis BMD 4.0 intercept flight testing to date. Aegis BMD has demonstrated the capability to plan for, detect, track, and engage non-separating and complex-separating SRBMs in the midcourse phase of flight. In total, Aegis BMD 4.0 ships intercepted three target ballistic missiles (one non-separating SRBM and two complex-separating SRBMs) in the midcourse phase with SM-3 Block IB interceptors. Aegis BMD 4.0 was also successful in engaging five live ballistic missile targets (three non-separating SRBMs and two complex-separating SRBMs) during simulated engagements.

Table 3-5. Aegis BMD 4.0 Intercept Flight Test Summary

Intercept Flight Test	Date	Target Threat Class	SM-3 Variant		Engagement Mode		Hit
			Block IB	Block IA	Organic	Remote	
FTM-16 Event 2	September 1, 2011	SRBM [a]	X		X		No
FTM-16 Event 2A	May 9, 2012	SRBM	X		X		Yes
FTM-18	June 26, 2012	SRBM [a]	X		X		Yes
FTM-20	February 12, 2013	MRBM [b]		X		X	Yes
FTM-19	May 15, 2013	SRBM	X		X		Yes
FTM-21	September 18 2013	SRBM	Salvo of Two [c]		X		Yes
FTM-22	October 3, 2013	MRBM	X		X		Yes

a SRBM with MRBM characteristics.
b Non-separating MRBM target.
c The second SM-3 Block IB interceptor experienced a failure of the third-stage rocket motor.

Aegis BMD has also demonstrated a capability to plan for, detect, track, and engage separating ballistic missile threats in the midcourse phase of flight at the lower MRBM ranges. In total, Aegis BMD 4.0 ships intercepted three out of four ballistic missile targets with ground ranges just below or around 1,000 kilometers. One of the three successful intercepts was made against a non-separating MRBM with an SM-3 Block IA interceptor, with the firing ship set up with remote engagements authorized to use forward-based data in the fire control loop. Aegis BMD 4.0 was also successful in engaging seven out of seven simple-separating MRBM-like SRBMs during simulated engagements against live ballistic missile targets.

The Aegis BMD 4.0 system's ability to engage longer-range MRBM threats is less certain than for lower-range threshold MRBMs because only one intercept mission has been attempted. The ship in that flight test was configured with remote engagements authorized and used a forward-based sensor to provide data to the ship. Finally, the flight test involved a

non-separating lower-range threshold MRBM. No intercept missions have been conducted against long-range MRBMs.[24] Modeling and simulation analyses, HWIL exercises, and use of legacy FTM-15 (FY11) data (from an IRBM engagement) provide a degree of certainty that the system can engage longer-range threats, but overall certainty is limited due to lack of end-to-end flight testing against these targets.

The lone failure to intercept in an Aegis BMD 4.0 flight test occurred during the first developmental flight test of the Aegis BMD 4.0 system in FY11. It led to the modification of the software controlling the inter-pulse delay between third-stage rocket motor (TSRM) burns. Those software modifications have been flight tested three times without incident. Table 3-6 summarizes the root cause of the FTM-15 Event 2 (FY11) and FTM-21 (FY13) failures.

Table 3-6. Aegis BMD Intercept Flight Test Failure Root Causes

Intercept Flight Test Failures and Anomalies	Failure/Root Cause
FTM-16 Event 2 (FY11)	SM-3 Block IB third-stage rocket motor energetic event. Asymmetric flow developed within the motor combustion chamber during the second of two axial thrust pulses. The asymmetric flow caused severe, localized erosion of the aft motor components, resulting in loss of vehicle control.[a]
FTM-21 (second missile) (FY13)	SM-3 third-stage rocket motor failure in the second of two salvo-launched SM-3 Block IB guided missiles. The failure was caused by asymmetric flow in the motor combustion chamber, but with a different area of erosion and failure mechanism than the failure in FTM-16 Event 2 (FY11).[b]

[a] The MDA addressed this failure by modifying the software controlling the inter-pulse delay between third-stage rocket motor burns.

[b] The MDA has re-designed the third stage rocket motor nozzle area, but the new design has not yet been flight tested.

Operational Suitability. Analysis of data obtained during flight testing and the maintenance demonstration showed that the Aegis BMD 4.0 system is suitable to meet availability specifications. Operational testers observed lower than desired command, control, communications, computers, and intelligence hardware reliability and undesirable BMD Signal Processor stability in early flight tests, but computed availability still meets the threshold value specified in the Aegis BMD 4.0 system specifications document. Also of note were Operational Readiness Test System (ORTS) deficiencies observed during testing that at times prevented ship operators from accurately assessing the overall status of the Aegis Weapon System. However, the ORTS deficiencies did not critically impact the execution of the tests.[25]

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24 An upper-threshold MRBM is defined as 1,500 to 3,000 kilometers in ground range.

25 ORTS is a computer-controlled test and monitor system that performs automatic fault detection, fault isolation, status monitoring, and system reconfiguration.

SM-3 missile failures encountered during flight testing of the Aegis BMD 4.0 system that relate to the TSRM have lowered certainty in the reliability of that SM-3 component.[26] The two TSRM failures were related to two-pulse operations of the TSRM. The FTM-16 Event 2 TSRM failure in FY11 was addressed by modifying the inter-pulse delay time to a larger minimum value. The modification has been flight tested five times without incident. This correction, however, did not prevent the TSRM failure in the second of two salvo-launched SM-3 Block IB guided missiles in FTM-21 in FY13, which suffered a reliability failure of the TSRM aft nozzle area during second pulse operations.[27] The MDA established a Failure Review Board to determine the root cause of this failure and the Board uncovered enough evidence to determine that a re-design of the TSRM nozzle could improve missile reliability. New design concepts have been generated and initial ground testing of them began in FY14.

Survivability. A four-part multi-warfare exercise during Aegis BMD 4.0 flight testing demonstrated a capability to perform simultaneous anti-air warfare ship self-defense and BMD functionality. The multi-warfare exercise also demonstrated the retention of legacy Aegis ship missions, while simultaneously performing BMD missions, in the areas of surface warfare, anti-surface warfare, undersea warfare, and electronic warfare.[28] Electronic warfare attacks were conducted against the participating ship's systems throughout all multi-warfare events, demonstrating the ability to detect, process, analyze, react to, and report electronic warfare threats while conducting combat operations. All exercise scenarios were conducted in an operationally realistic manner. Live or simulated threat-representative targets were launched without notice to the ship's crew; operational tactics, techniques, and procedures were followed; and operational hardware and software were present on the ship. However, the multi-warfare exercise scenarios were not stressing in terms of BMD system resources, so they are not indicative of system performance in a more stressing combat environment (e.g., a raid of ballistic missiles with cruise missiles).

As was the case for the Aegis BMD 3.6 system, testing of the 4.0 system to date occurred during available weather conditions, which in most cases did not reach stressing levels of rain, sea state, or other environmental conditions. As a result, an assessment of survivability under extreme environmental conditions is not possible. Other environmental testing shortfalls that limit an assessment of overall system survivability include tests to determine the effects of nuclear, biological, and chemical environments, as well as realistic testing conducted in a Global Positioning System-denied environment.

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26 The TSRM is common to both the SM-3 Block IA and SM-3 Block IB missiles.

27 The first SM-3 Block IB guided missile had already achieved a successful intercept prior to the second SM-3 Block IB TSRM failure.

28 Surface warfare activities included detecting mine hazards and conducting simulated firings against surface ships deploying mines. Anti-surface warfare activities included detecting and engaging high-speed maneuvering surface targets with the ship's two 5-inch guns. Undersea warfare activities included engaging a submarine threat.

Terminal High-Altitude Area Defense (THAAD)

This report characterizes THAAD capability against SRBMs using primarily intercept flight tests against threat-representative targets, including seven flight tests.[29] All of these flight tests were against short-range targets, although two targets exhibited medium-range target characteristics. THAAD capability against MRBMs is characterized using primarily Flight Test, Integrated-01 (FTI-01, FY13) and FTO-01 (FY13), with supporting data from FTT-09 (FY08) and FTT-12 (FY12).[30] The targets in Flight Test, THAAD-09 (FTT-09, FY08) and FTT-12 (FY12) flew short-range trajectories, but each had a reentry vehicle that exhibited medium-range target characteristics. IRBMs are a part of the THAAD threat set, but THAAD has not performed any flight testing against IRBM targets to date. The first flight test against an IRBM is scheduled for 2015. This report also considers data from other tests, such as early THAAD flight tests, live fire test and evaluation, ground qualification testing, and track exchange exercises with Aegis BMD, as well as M&S. This year's assessment has not changed significantly from last year because no THAAD flight testing has been performed. FY14 ground testing and M&S have provided useful supporting data but do not indicate any major changes in capability.

All testing described above with the exception of FTO-01 (FY13) and some recent ground testing was performed with the THAAD Configuration 1 system. The Army issued a conditional materiel release to the first two THAAD Configuration 1 batteries in February 2012, and the first deployment took place in April 2013. THAAD Configuration 2 is in testing and was used for the first time in FTO-01 (FY13). Since THAAD Configuration 2 is a spiral development effort based on THAAD Configuration 1, most of the THAAD Configuration 1 testing is relevant to THAAD Configuration 2. More dedicated THAAD Configuration 2 testing will be required for a full characterization since THAAD Configuration 2 contains new debris mitigation algorithms to improve performance against raids of threat ballistic missiles.

<u>Operational Effectiveness</u>. Currently, THAAD has demonstrated the capability to plan for, detect, track, and engage short-range non-separating, short-range simple-separating, and medium-range targets. In the 9 flight tests shown in Table 3-7, THAAD intercepted all 10 target ballistic missiles (5 short-range non-separating ballistic missiles, 3 short-range simple-separating ballistic missiles, and 2 medium-range ballistic missiles). Two of the short-range simple-separating targets replicated some medium-range target endgame performance characteristics. One flight test (FTT-10a, FY09) successfully demonstrated a salvo engagement of two THAAD interceptors against a single target, which is consistent with potential tactical operations. Another flight test (FTT-12, FY12) successfully demonstrated a multiple simultaneous engagement of two THAAD interceptors against two targets. THAAD has also demonstrated a capability to intercept threat missiles both inside and outside the atmosphere (endo- and

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29 The seven flight tests were FTT-06 (January 26, 2007), FTT-07 (April 5, 2007), FTT-08 (October 26, 2007), FTT-09 (June 25, 2008), FTT-10a (March 17, 2009), FTT-14 (June 29, 2010), and FTT-12 (October 4, 2011).

30 The MDA executed FTI-01 on October 25, 2012, and FTO-01 on September 10, 2013. The MDA conducted FTT-09 on June 25, 2008, and FTT-12 on October 4, 2011.

exo-atmospheric, respectively), the only BMDS weapon element specifically designed with this capability.

Although THAAD has performed eight successful engagements against threat-representative SRBM targets, a full characterization of effectiveness against SRBMs will require flight tests using the Radar's advanced algorithms against more complex SRBMs. The target types flown to date have not required use of the advanced algorithms. A test designed to invoke the algorithms is scheduled in 2015. The testing completed to date demonstrates a capability against MRBMs for THAAD, but the MDA needs to perform more testing for a comprehensive characterization. A characterization of effectiveness against MRBMs will also need to include more complex targets and exploration of other parts of the battlespace particularly relevant to these longer, faster threats. Although some HWIL ground testing has been conducted for THAAD against IRBM targets, no flight testing of this capability has taken place. As a result, the effectiveness of THAAD against IRBMs cannot be determined.

Table 3-7. THAAD Intercept Flight Test Summary

Intercept Flight Test	Date	Target Type	Intercept Altitude		Hit
			Endo	Exo	
FTT-06	January 26, 2007	SRBM	High		Yes
FTT-07	April 5, 2007	SRBM	Mid		Yes
FTT-08	October 26, 2007	SRBM		x	Yes
FTT-09	June 25, 2008	SRBM [a]	Mid		Yes
FTT-10a	March 17, 2009	SRBM	Mid		Yes
FTT-14	June 29, 2010	SRBM	Low		Yes
FTT-12	October 4, 2011	SRBM [a] SRBM	Mid High		Yes Yes
FTI-01	October 25, 2012	MRBM	High		Yes
FTO-01	September 10, 2013	MRBM		x	Yes

[a] SRBM with MRBM characteristics.

Operational Suitability. In FY/CY14, the THAAD program made progress in resolving some of the 31 suitability-related conditions that the Army designated necessary for the system to improve following the conditional materiel release decision.[31] Progress has been made in

[31] There are 39 total U.S. Army materiel release conditions for THAAD, 6 effectiveness conditions, 31 suitability conditions, and 2 survivability conditions. DOT&E also made recommendations for THAAD in the February 2012 classified Operational Test and Evaluation Report. Fifteen of the recommendations align directly with the Army materiel release conditions. The additional seven contain two effectiveness, three suitability, and two survivability recommendations. Several of the issues mentioned in this section are tracked

safety verification of the technical manuals, developing a configuration control system for the software and firmware, developing procedures for missile field and storage inspection, and fixing messaging issues. However, completion of all 31 conditions is not currently scheduled until FY17. DOT&E also had three additional suitability recommendations in the February 2012 Operational Test and Evaluation Report for THAAD that do not directly align with the materiel release conditions and still need improvement.

The current THAAD personnel structure is not adequate to ensure timely and sufficient deployment and operation of a THAAD battery. Although THAAD is assigned to an Army battalion, the battalion was created for Patriot, and so it does not have a detailed understanding of unique THAAD requirements. The Army Operational Test Agency has observed that some Soldiers have assumed THAAD battalion duties without THAAD training. Some THAAD training aids and devices are not currently available and are not scheduled to become available for several years.

The mission software reporting of the operational capability of the system components is insufficient to enable Soldiers to assess the status of the equipment. Specific instances of incorrect and inconsistent reporting were observed during testing. Some critical faults were not relayed through the system at all.

Analyses of data from the Reliability Confidence Test, FTT-12 (FY12), FTI-01 (FY13), and FTO-01 (FY13) suggest that the system components are not exhibiting consistent nor steadily increasing reliability between test events. Several THAAD components do appear to have adequate Mean Time Between Essential Function Failure and Mean Time To Repair values, but others are inconsistent and may be inadequate.

A number of shortfalls that affect sustainability continue to be identified in the documentation (manuals and users guides), although the documentation is showing some improvement with time. The division of labor between Soldiers, contractor support, and reach-back contractor support is heavily skewed toward contractor support and reach-back contractor support.

Mobility and transportability testing has been largely successful, and march order times indicate that the system is generally capable of movement and maneuver.

Few health and safety concerns were uncovered in testing, suggesting the system is generally safe to operate and presents little undue health hazard.

Until the MDA implements redesigns, the system could experience excessive faults and repairs in inclement weather. The MDA subjected THAAD to natural environments testing, which included temperature extremes, temperature shock, humidity, rain, ice, snow, sand, dust, and wind. The MDA found deficiencies in all areas except for wind, resulting in many redesign

by the materiel release review process and work is being done to resolve them. They will be continued to be monitored and reported upon by DOT&E until they have been successfully tested.

recommendations. Design improvements have been implemented that corrected many of the issues experienced during the testing.

Survivability. THAAD has completed testing and analysis to determine survivability against hostile environments, including exposure to chemical, biological, and radiological exposure and electromagnetic environmental effects, and against a direct information assurance attack, including insider and outsider network attacks and network exploitation. Testing has not been performed in an electronic countermeasure environment.

Subject matter experts from the Army West Desert Test Center determined that the THAAD system can be decontaminated from exposure to chemical, biological, and radiological elements within the Army-approved contamination criteria timeline, as long as separate teams work on each major component simultaneously. The THAAD system is also expected to meet the materiel hardness criterion and the compatibility criterion that specified minimum degradation of crew performance while wearing protective gear.

Patriot

The Patriot assessment is based primarily on demonstrated performance during the PDB-7 Limited User Test (LUT), conducted between May 2012 and January 2013. The test data are unchanged from last year but the assessment is slightly different because of differences between the Capability Development Document (CDD) that was approved in FY14 and previous requirements documents.

Operational Effectiveness. Patriot meets the Capability Development Document's system effectiveness requirements against some tactical ballistic missiles. However, Patriot fails to fully meet requirements against other tactical ballistic missiles and therefore has limited effectiveness against selected threats. Patriot Advanced Capability-3 (PAC-3) has demonstrated the capability to engage tactical ballistic missiles in flight tests against more than 30 SRBM targets since 1999. One flight test was conducted against an MRBM target in 2002. Sixteen flight tests since 2000 featured multiple simultaneous Patriot engagements against two targets. Patriot was used in combat during Operation Iraqi Freedom (OIF) in 2003. Iraq launched nine SRBMs against Patriot defended assets during OIF and Patriot intercepted all nine but it also shot down two friendly aircraft due to a combination of training and system shortfalls. Patriot has implemented several enhancements and nine corrective actions to prevent future fratricide incidents.[32]

Operational Suitability. Patriot did not meet its operational requirements for reliability, maintainability, or availability during the PDB-7 LUT (FY12-13). More than 70 percent of the critical mission failures during the PDB-7 LUT (FY12-13) were experienced by the radar. If the radar had achieved the allocated reliability then the Patriot battery would have exceeded the threshold reliability requirement. The Army plans to field the Patriot Radar Digital Processor

32 Detailed information regarding these corrective actions can be found in the 2002 Report to House Armed Services Committee Operation Iraqi Freedom (OIF) Patriot System Corrective Actions.

(RDP) upgrade with PDB-8 in FY18. The RDP is expected to enhance reliability and reduce maintenance overhead for the Patriot radar. Patriot supportability and transportability were satisfied through testing prior to the IOT&E in 2002. Patriot met some of its manpower, personnel, and means of employment requirements. However, PDB-7 software increases operator workload and requires additional manpower. The LUT (FY12-13) highlighted the growing complexity of the Patriot system, which requires a level of operator expertise that exceeds the current training. Due to the high demand for operational Patriot units in the field, the Army also lacks a dedicated test unit for Patriot.

Survivability. The Patriot system has not yet demonstrated that it can meet the requirements to survive certain electromagnetic environments, some of which were added after the Army designed and tested the Patriot system. Patriot, being a legacy system, did not meet the BMDS or certain Army Nuclear and Chemical Agency requirements. The Army granted a waiver for the deficient requirements. The Army Nuclear and Chemical Agency supported the waiver.

Section Four
Assessment of Ballistic Missile Defense System (BMDS) Test Program Adequacy

This section of the report addresses the fiscal year 2002 (FY02) National Defense Authorization Act (NDAA) mandate for the DOT&E to assess the adequacy and sufficiency of the BMDS Test Program. This assessment is in terms of three critical attributes: scope, operational realism, and demonstrated testing, and by examining a series of measures of merit for each.

Synopsis

The Ground-based Midcourse Defense (GMD) test results are partially adequate to support assessment of the operational effectiveness, suitability, and survivability of the BMDS to defend the U.S. Homeland against Intermediate-Range Ballistic Missile (IRBM) and Intercontinental Ballistic Missile (ICBM) threats. Flight Test, Ground-Based Interceptor (GBI)-06b (FTG-06b, FY14) provided a limited demonstration of GBI intercept capability. Although FTG-06b (FY14) data will be useful for verification, validation, and accreditation (VV&A) of modeling and simulation (M&S) of future deployed GBIs in the FTG-06b (FY14) configuration, use of a more stringent screening process for the Exo-atmospheric Kill Vehicle (EKV) batteries and new inertial measurement unit (IMU) firmware and mounting hardware were not representative of the currently fielded GBIs; hence some data cannot be used for current VV&A. Further, FY/CY14 testing did not advance the VV&A of multiple other M&S that are needed for a BMDS performance assessment because test failures precluded collection of flight test data needed for VV&A of IRBM and ICBM threat dynamics and signatures, multiple radar M&S, and atmospheric environments.

Flight testing of the Regional/Theater BMDS autonomous combat systems is sufficient to support a quantitative assessment of the systems' performance against Short-Range Ballistic Missile (SRBM) and Medium-Range Ballistic Missile (MRBM) threats.[33] Flight testing is currently inadequate to provide quantitative assessments of effectiveness against IRBM threats. The Missile Defense Agency (MDA) has two flight tests planned for 2015 that will collect data to alleviate this shortfall.

Critical Attributes of the BMDS Test Program

BMDS test program adequacy can be assessed in terms of three critical attributes: scope, operational realism, and demonstrated testing. Scope can be characterized by considering four key measures of merit: 1) the degree of critical data collected, 2) the breadth of battlespace tested, 3) the extent of the threat set covered, and 4) the span of BMDS capabilities

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[33] Regional/Theater autonomous combat systems are Aegis Ballistic Missile Defense (BMD), Terminal High-Altitude Area Defense (THAAD), and Patriot. Previous test results and data were documented in individual DOT&E Initial Operational Test and Evaluation technical reports.

demonstrated. This section focuses on the first of these measures of merit, the collection of data to support VV&A of M&S necessary to quantitatively evaluate the effectiveness of the BMDS and its elements. Appendix C addresses the other measures of merit for the critical attribute of scope.

The FY05 NDAA directed the MDA to conduct "operationally realistic testing" of the BMDS. In response, DOT&E and the MDA developed a set of measures of merit originally oriented solely toward Homeland Defense, that is, GMD countering IRBM and ICBM threat ballistic missiles. A small broadening of the definition of the nine original measures of merit makes them applicable to any BMDS flight test. Since FY06, DOT&E has applied these measures of merit to assessing the BMDS test program adequacy. The nine metrics are flight test use of: 1) operationally representative interceptors; 2) threat-representative targets; 3) complex countermeasures; 4) operational sensors; 5) operational fire control software; 6) warfighter-approved tactics, techniques, and procedures; 7) warfighter participation; 8) unannounced target launch; and 9) end-to-end test.[34]

Starting in FY/calendar year (CY) 2012, this report began including demonstrated testing of the BMDS as a measure of the maturity, complexity, and rigor of its test program. This section presents a five-year history of the evolution of BMDS testing against SRBM, MRBM, IRBM, and ICBM threat ballistic missiles.

Scope

As stated in the Integrated Master Test Plan (IMTP), the main purposes of the BMDS test program is to collect the critical data needed for VV&A of the M&S required to assess BMDS performance across its entire battlespace, a task which cannot be achieved through flight testing alone. M&S can examine scenarios that flight tests cannot because of geographic or test safety constraints. To quantify the operational effectiveness, operational suitability, and survivability of the BMDS and its elements, an adequate test program must include M&S that have been fully accredited for performance assessment purposes by an independent agency such as the BMDS Operational Test Agency (OTA). The BMDS OTA must accredit over 40 component, element, lethality, threat, and environmental models in order to use them to assess BMDS and element performance. Hence, collecting the critical data needed for VV&A and the associated status of M&S is a critical measure for assessing the BMDS test program adequacy.

Ground-based Midcourse Defense (GMD). GMD intercept flight testing remains inadequate to support progress toward VV&A of EKV M&S since January 2010 because GBI intercept flight test failures precluded collection of EKV flight test data needed for VV&A. In FY/CY14, the MDA collected useful GMD intercept flight test data from FTG-06b (FY14). However, some aspects of the FTG-06b (FY14) GBI's EKV configuration were not representative of the currently fielded GBIs and cannot be used for VV&A of current M&S of

34 Joint MDA and DOT&E Memorandum, "Ballistic Missile Defense System, Response to Sec. 234, Increasing Operational Realism," version 1.5, April 4, 2005.

the fielded system.[35] Nevertheless, the FTG-06b (FY14) data will be beneficial for VV&A of models and simulations of GBIs in the FTG-06b (FY14) configuration. Additionally, a lack of sufficient fidelity in the current environmental models prevents the accurate prediction of how systems would perform in an operational setting.

The IMTP identifies intercept flight tests that are needed to achieve VV&A of GMD models and simulations, but the MDA will need several intercept flight tests in a consistent configuration to achieve VV&A of the GBI models and simulations over a limited portion of the operational threat engagement battlespace. The MDA currently plans 10 GMD flight tests through FY/CY24 including a salvo engagement test, a test engaging multiple simultaneous threats, and an ICBM engagement test. These GMD flight tests are required to support the VV&A of GMD M&S over the IRBM and ICBM engagement battlespace.

The VV&A status of the M&S needed for GMD performance assessment remains largely the same as in prior years:

- GMD EKV M&S could not be assessed for accreditation due to lack of verification evidence for the latest updated models (CE-I MFSim v20.9 to v22.0, CE-II MFSim v9.2 to v9.4)
- Limited accreditation for the Upgraded Early Warning Radar (UEWR), the Sea-Based X-band (SBX) radar, and the COBRA DANE radar M&S
- Accreditation for performance assessment for M&S of IRBM and ICBM threat dynamics, and limited accreditation for threat signatures
- Full accreditation for 3, limited accreditation for 18, and no accreditation for 9 environmental M&S

Aegis Ballistic Missile Defense (BMD). As was the case for the Aegis BMD 3.6 system in FY/CY08, the flight test program for the Aegis BMD 4.0 system, which was completed in FY14, was adequate to demonstrate a broad range of system capabilities and allow the MDA to perform a verification and validation of the core Aegis BMD M&S suite in support of accreditation by the Commander, Operational Test Force (COTF). In August 2014, COTF accredited the suite of models and performed testing to support the evaluation of the Aegis BMD 4.0 system in conducting organic and remote engagement, and long-rang surveillance and track scenarios.[36]

In their accreditation report, COTF noted several limitations. Two specific limitations are particularly noteworthy. First, simultaneous engagement of anti-air warfare (AAW) and

35 The MDA applied a more stringent screening process to the EKV batteries prior to FTG-06b (FY14) than was applied to the EKV batteries in the currently fielded GBIs. In addition, the FTG-06b (FY14) EKV was configured with new IMU firmware and mounting hardware to mitigate problems that were discovered subsequent to the FTG-06a (FY11) failure. These features represent significant differences between the FTG-06b (FY14) test GBI and all of the fielded GBIs.

36 Aegis BMD Baseline 4.0 System Modeling and Simulation Accreditation Report, August 2014.

BMD threats were not modeled. As a result, the impacts of AAW tasking on performance of the BMD mission, and vice versa, cannot be investigated. An assessment of BMD capability in the absence of AAW tasking can still be made. Second, post-intercept debris was not modeled. Post-intercept debris can present a challenge to AN/SPY-1 radar performance and Aegis BMD logic during scenarios involving multiple threat missiles.

DOT&E assesses that the Aegis BMD models should only be used to extrapolate performance for engagements with threat ground ranges up to about 1,700 kilometers, and for engagements that have scenario geometries that are similar to those flight tested. Moreover, the specific types of engagement that are possible in a given scenario should be flight tested.[37] The 1,700 kilometer threat range cutoff is warranted by two factors: 1) anchoring data for threats flying 1,200 kilometers exist, the engagement battlespace (e.g., closing velocity) is not expected to be drastically different when engaging identical threats which fly 1,700 kilometers, and 2) flight test results for intercept engagements against 1,200 kilometer targets indicate that the system has a performance margin that should allow extrapolation out another 500 kilometers in threat range. Similarly, the restriction to similar engagement geometries and types flight tested ensure that M&S data from portions of the battlespace not anchored by flight test are not relied upon for performance assessments. The implications of these limitations to the applicability of the M&S analyses performed as part of Initial Operational Test and Evaluation (IOT&E) of the Aegis BMD 4.0 system are discussed in Appendix B.

Terminal High-Altitude Area Defense (THAAD). All THAAD M&S used for performance assessment undergo verification and validation continuously as flight and ground testing progresses, and accreditation is updated as needed. The Army Test and Evaluation Command (ATEC) and the BMDS OTA conducted an independent accreditation of THAAD M&S before using the data in their December 2011 Assessment Report in support of the fielding decision for the first two THAAD batteries. It accredited, with limitations, the Simulation-Over-Live-Driver, Integrated Simulation and Tactical Software, THAAD Evaluation Center Hardware-in-the-Loop (HWIL) and Imaging Infrared Simulation, and Parametric Endo-/Exo-atmospheric Lethality Simulation for autonomous THAAD performance against the types of threats emulated in testing, which at the time were all SRBMs. For system-level venues, the BMDS OTA has recommended limited accreditation of the Integrated Simulation and Tactical Software model.

The Flight Test, Integrated-01 (FTI-01, FY13) and Flight Test, Operational-01 (FTO-01, FY13) flight tests allowed the MDA and the BMDS OTA to VV&A and give limited accreditation to THAAD M&S for performance against some MRBMs, although more flight testing will be needed. Some additional MRBM information is attainable from Flight Test, THAAD-09 (FTT-09, FY08) and FTT-12 (FY12), for which the targets flew short-range trajectories but exhibited primarily medium-range target characteristics.

37 For example, all types of remote engagement (cued, launch on remote, and engage on remote) need to be flight tested to sufficiently anchor the M&S suite for performance analysis of remote engagement scenarios, since any given scenario could result in any of the three types of remote engagement.

The MDA has not conducted any THAAD flight testing against IRBM targets; the first flight test is scheduled for August 2015. Some THAAD simulations during ground testing have included IRBM targets, but VV&A of performance against IRBM targets cannot be completed without additional testing.

Patriot. ATEC accredited the Post-Deployment Build-7 (PDB-7) version of the Mobile Flight Mission Simulator HWIL system in May 2012, the Patriot Advanced Capability-2 (PAC-2) simulation and PAC-3 simulation in August 2012, the Parametric Endo-/Exo-atmospheric Lethality Simulation in October 2012, and the Lethality Endgame Simulation in December 2012. For BMDS-level venues, the BMDS OTA has not recommended full accreditation of the Patriot System Effectiveness Model. The Flight Mission Simulator/Digital was used in system-level integrated ground tests to test Patriot interoperability, not performance, with other BMDS elements, but the simulator has not yet been accredited for use in BMDS-related events. ATEC did provided a limited accreditation of the simulator for use during the PDB-6 LUT in 2007.

Operational Realism

The FY05 NDAA directed the MDA to conduct "operationally realistic testing" of the BMDS, and in response, DOT&E and the MDA developed a set of measures of merit to quantify the operational realism of a flight test. Table 4-1 summarizes these criteria. Table 4-2 shows the operational realism assessments for the flight tests conducted during FY/CY14.

FTG-06b (FY14), Standard Missile-3 (SM-3) Cooperative Development Propulsion Test Vehicle-01 (SCDPTV-01, FY14), and Aegis Ashore Controlled Vehicle Test-01 (AA CTV-01, FY14) were considered developmental tests; FTO-01 (FY13), Flight Test, Maritime-22 (FTM-22, FY14), Flight Test, Other-18 (FTX-18, FY14), and FTM-25 (FY15) were considered exclusively operational tests; while FTX-20 (FY14) was a combined developmental/operational test. The Medium Extended Air Defense System (MEADS) Flight Test-2 (FT-2, FY14) was considered a capabilities demonstration. The "Partially Achieved" rating for the interceptor in FTM-25 (FY15) was given because the SM-3 Block IB guided missile fired in the test did not have the Threat Update software, and thus the interceptor was not fully representative of the configuration that will be fielded with the Aegis Combat System (ACS) BL9.C1 system. The "Partially Achieved" rating for Operational Fire Control Software in both FTX-20 (FY14) and FTM-25 (FY15) was given because the ACS BL9.C1 system has not yet been certified for operational use; certification is expected to take place in 2015.

Table 4-3 provides a consolidation of the operational realism of flight tests since FY/CY10. Specifically, it shows the percentage and number of times a flight test achieved or partially achieved a particular criterion.

Table 4-1. Operational Realism Criteria for BMDS Flight Testing

Operational Realism Criteria	Description
Operationally Representative Interceptors	Operationally representative interceptors modified to support mandatory flight safety and data collection requirements
Threat-Representative Targets	Threat-representative target trajectories, signatures, complexities, and scenarios
Complex Countermeasures	Use of target dynamics and penetration aids
Operational Sensors	Appropriate sensors meeting range safety and truth data requirements
Operational Fire Control Software	Fully tested and certified through the formal software acceptance process
Tactics, Techniques, and Procedures	Operationally representative tactics, techniques, and procedures within test constraints
Warfighter Participation	Operationally realistic (i.e., real world) scenarios using trained and, if possible, operational warfighters
Unannounced Target Launch	Minimum scripting with concurrent reduction in the quantity of a priori information provided to the defensive operations
End-to-End Test	Direct use of appropriate operational assets while minimizing the introduction of artificialities

Table 4-2. Operational Realism Assessment for FY/CY14 Flight Tests

Operational Realism Criteria	BMDS		Aegis BMD/ACS					Aegis Ashore	Patriot
	FTG-06b	FTO-01	FTM-22	SCDP TV-01	FTX-18	FTX-20	FTM-25	CTV-01	MEADS FT-2
Representative Interceptors	✓	✓	✓	DT	N/A	N/A	P	DT	N/A
Threat Representative Targets	DT	✓	✓	N/A	✓	P	✓	N/A	N/A
Complex Countermeasures	N/A	N/A	N/A	N/A	N/A	N/A	NA	N/A	N/A
Operational Sensors	P	✓	✓	N/A	✓	✓	✓	DT	N/A
Operational Fire Control Software	✓	✓	✓	DT	✓	P	P	DT	N/A
Tactics, Techniques, and Procedures	P	✓	✓	DT	✓	✓	✓	DT	N/A
Warfighter Participation	P	✓	✓	N/A	✓	✓	✓	DT	N/A
Unannounced Target Launch	DT	✓	✓	N/A	✓	✓	✓	N/A	N/A
End-to-End Test	✓	✓	✓	N/A	N/A	N/A	✓	N/A	N/A

✓—Achieved P—Partially Achieved DT—Developmental Test N/A—Not Applicable NT—Not Tested

Table 4-3. Operational Realism Assessment for Intercept Flight Tests Since FY/CY10

Operational Realism Criteria	GMD			Aegis BMD/ACS			THAAD			Patriot		
	✓	P	DT, N/A, or NT	✓	P	DT, N/A, or NT	✓	P	DT, N/A, or NT	✓	P	DT, N/A, or NT
	4 total tests			11 total tests			4 total tests			13 total tests		
Representative Interceptors	75% (3)	25% (1)	0% (0)	73% (8)	27% (3)	0% (0)	100% (4)	0% (0)	0% (0)	92% (12)	8% (1)	0% (0)
Threat Representative Targets	0% (0)	0% (0)	100% (4)	73% (8)	27% (3)	0% (0)	100% (4)	0% (0)	0% (0)	92% (12)	8% (1)	0% (0)
Complex Countermeasures	0% (0)	0% (0)	100% (4)	0% (0)	0% (0)	100% (11)	0% (0)	0% (0)	100% (4)	0% (0)	0% (0)	100% (13)
Operational Sensors	0% (0)	75% (3)	25% (1)	91% (10)	9% (1)	0% (0)	100% (4)	0% (0)	0% (0)	100% (13)	0% (0)	0% (0)
Operational Fire Control Software	100% (4)	0% (0)	0% (0)	64% (7)	36% (4)	0% (0)	100% (4)	0% (0)	0% (0)	100% (13)	0% (0)	0% (0)
Tactics, Techniques, and Procedures	25% (1)	25% (1)	50% (2)	64% (7)	36% (4)	0% (0)	100% (4)	0% (0)	0% (0)	100% (13)	0% (0)	0% (0)
Warfighter Participation	75% (3)	25% (1)	0% (0)	91% (10)	9% (1)	0% (0)	100% (4)	0% (0)	0% (0)	85% (11)	0% (0)	15% (2)
Unannounced Target Launch	75% (3)	0% (0)	25% (1)	73% (8)	0% (0)	27% (3)	100% (4)	0% (0)	0% (0)	0% (0)	23% (3)	77% (10)
End-to-End Test	25% (1)	0% (0)	75% (3)	91% (10)	9% (1)	0% (0)	100% (4)	0% (0)	0% (0)	100% (13)	0% (0)	0% (0)

✓—Achieved P—Partially Achieved DT—Developmental Test N/A—Not Applicable NT—Not Tested

Figure 4-1 graphs the percentage of tests covered by Table 4-3 that were rated "achieved" by the BMDS combat system. For example, 100 percent of GMD, Aegis BMD, THAAD, and Patriot tests met at least zero or one of the realism criteria (a trivial result). Only 50 percent of the GMD tests (2 out of 4), however, achieved a check mark for 4 or more operational realism criteria. None of the GMD tests conducted during the previous five years achieved a check mark for six or more operational realism criteria. Contrast this with THAAD, where every test achieved a check mark for eight of the nine criteria. Note that no flight test achieved all nine

criteria since there was no flight test that included complex countermeasures during the five-year period covered in Table 4-3.

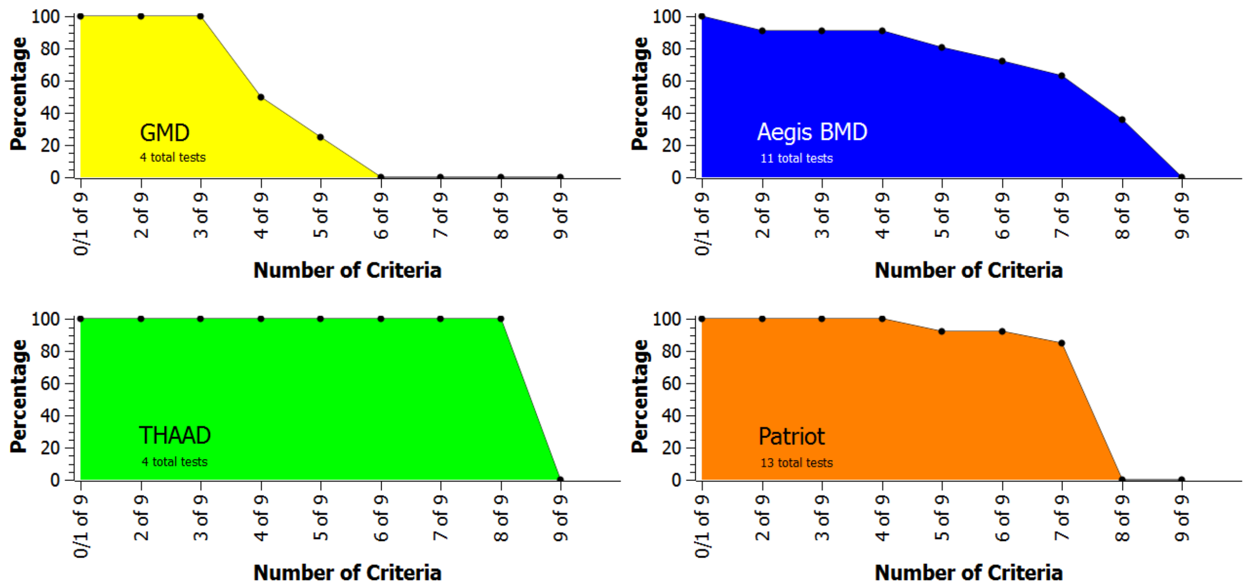

Figure 4-1. Percentage of Tests Achieving Operational Realism Criteria since FY/CY10.

Figure 4-1 shows that the Regional/Theater weapon elements are achieving more operational realism criteria in their flight test events compared to GMD. Starting with the failure in FTG-06 (FY10), GMD flight testing has been focused on attempts to address the shortcomings uncovered during this test, which partially accounts for the results shown in the figure. The figure also shows that THAAD achieved the highest percentage of "achieved" ratings for the highest number of operational realism criteria compared to the other weapon elements.

Demonstrated Testing by Threat Class

As in previous BMDS Annual Reports, this section assesses demonstration of autonomous combat system capability in terms of six levels. Table 4-4 defines and summarizes the key characteristics of the capability demonstration levels from lowest to highest level of demonstrated testing, technical rigor, test complexity, and operational realism.

- Level 1 is the lowest level of demonstrated testing and is achieved through analysis, laboratory testing, and/or legacy system models and simulations. Such demonstrations provide a proof-of-concept that a desired capability is possible.
- Level 2 is achieved through flight testing with developmental or legacy system hardware/software. It includes flight testing incorporating only components or subsystems of the BMDS. A complete developmental system is not a prerequisite for achieving Level 2.

- Level 3 exists when key components (e.g., the interceptor, sensor, or fire control software) under test are representative of the intended operational configuration. Flight testing at this level incorporates developmental testing (DT) combined with operational testing (OT). Flight testing can incorporate some operational objectives, but the emphasis and priority is on developmental objectives. Achieving this level is considered insufficient to demonstrate that an operationally useful defense capability exists.
- Level 4 consists of operationally realistic intercept flight testing with the intended operational components. This testing emphasizes and prioritizes operational objectives over developmental objectives. In addition, Level 4 includes ground tests and/or models and simulations to help assess the capability of the weapon element. Because this level of demonstration occurs during the development phase, an independent agency such as the BMDS OTA need not have accredited these ground tests and models and simulations for performance assessment purposes. Level 4 is the first level to demonstrate that an actual combat capability exists, although this capability might be rudimentary and is likely not very robust. The suitability and survivability of this weapon element is probably undetermined, and the effectiveness is likely estimated based on only a few flight tests. An autonomous combat system can be assessed at Level 4 for several years as the MDA collects verification and validation data to support accreditation of models and simulations by an independent agency. Such an accreditation is necessary for promotion to Level 5.
- Level 5 consists of a broad, but incomplete, demonstration of weapon element capabilities through the use of independently accredited ground tests and/or models and simulations. Such accreditations are possible only if a sufficient quantity and quality of flight test data have been collected to verify and validate the models and simulations.[38] These data are generally the result of operational testing but are supplemented with developmental testing. A credible threat-class-specific combat capability is demonstrated at this level, although it is likely somewhat limited. Estimates of effectiveness, suitability, and survivability can be expected at this level, although these estimates might be preliminary with correspondingly large uncertainties and therefore limited operational utility. Operationally useful capabilities for specific regions of the battlespace cannot be assessed with the currently demonstrated capability. However, for the parts of the battlespace where the capability has been demonstrated, a moderately robust combat capability has been demonstrated.

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[38] Ground tests and M&S can be accredited for many purposes. Here, it is meant that the ground tests and models and simulations have been accredited for performance assessment purposes. Verification is the process of determining that a M&S implementation accurately represents the developer's conceptual description and specifications. Validation is the process of determining the degree to which a M&S is an accurate representation of the real world from the perspective of the intended uses of the model.

- Level 6, the highest capability demonstration level, is a demonstration of autonomous combat system capabilities that can be fully integrated with the BMDS through operational flight tests, independently accredited ground testing, and/or M&S across the entire battlespace yielding a credible and sustainable combat capability.

Table 4-4. Demonstrated Testing Level Definitions

<table>
<tr><th rowspan="2">Level</th><th colspan="4">Description and Key Characteristics</th></tr>
<tr><th>Accreditation of M&S</th><th>Demonstrated Capability</th><th>Hardware/Software Components</th><th>Testing Rigor</th></tr>
<tr><td rowspan="2">6</td><td colspan="4">Autonomous combat system capability verified through integrated, operational test (OT), and independently accredited ground testing and/or models and simulations. The comprehensive set of defined weapon element requirements have been tested, and the combat system can be fully integrated into the BMDS. A credible and sustained combat capability has been demonstrated.</td></tr>
<tr><td>Independent Accreditation</td><td>Comprehensive</td><td>Full Operational Set with BMDS Integration</td><td>Integrated OT</td></tr>
<tr><td rowspan="2">5</td><td colspan="4">Broad, but incomplete, demonstration of autonomous combat system capabilities through independently accredited ground testing and/or models and simulations. Accreditation is possible only if a sufficient quantity and quality of flight test data have been collected to support model verification and validation. Limited combat operations capability has been demonstrated.</td></tr>
<tr><td>Independent Accreditation</td><td>Broad but Incomplete</td><td>Full Operational Set</td><td>OT</td></tr>
<tr><td rowspan="2">4</td><td colspan="4">Specific, limited autonomous combat system capabilities demonstrated through operationally realistic intercept flight testing with the full set of operational components. Flight testing emphasizes operational objectives over developmental test (DT). Ground testing and/or models and simulations need not be independently accredited and may be used for preliminary assessments. Emergency combat operations capability has been demonstrated.</td></tr>
<tr><td>Limited Accreditation</td><td>Specific/Limited/Operationally Realistic</td><td>Full Operational Set</td><td>Combined dt/OT</td></tr>
<tr><td rowspan="2">3</td><td colspan="4">Specific, limited autonomous combat system capabilities demonstrated through flight testing with key operational components. Flight testing emphasizes developmental objectives over operational objectives. Flight test data obtained are expected to contribute to independent accreditation of models and simulations used for assessing performance.</td></tr>
<tr><td>No Accreditation Required</td><td>Specific/Limited</td><td>Key Operational Set</td><td>Combined DT/ot</td></tr>
<tr><td rowspan="2">2</td><td colspan="4">Specific autonomous combat system capabilities demonstrated through developmental flight testing with developmental or legacy system hardware/software. The flight test data obtained support the development of engineering versions of models and simulations.</td></tr>
<tr><td>Engineering M&S</td><td>Specific</td><td>Developmental or Legacy</td><td>DT</td></tr>
<tr><td rowspan="2">1</td><td colspan="4">Autonomous combat system concept defined with capabilities estimated through analysis, laboratory testing, and/or legacy system models and simulations.</td></tr>
<tr><td>Legacy M&S</td><td>Concept Only</td><td>Analysis, Laboratory, or Legacy</td><td>Laboratory</td></tr>
</table>

Table 4-5 shows the relationship between autonomous combat systems, their designed intercept phase, and the types of threats they will intercept in the specified phase of flight. In the case of Aegis BMD, the interceptor type is also shown. Each cell is color-coded according to its current demonstrated testing. Cells that are not colored indicate no capability against the particular threat class and are labeled "N/A" for "Not Applicable." The cells that have a heavy line border are element versions that are currently deployed. Split cells show areas where the demonstrated capability has increased during FY14.

Table 4-5. Demonstrated Testing by Element, Intercept Phase, and Threat

Element	Intercept Phase	Threat Type			
		SRBM	MRBM	IRBM	ICBM
GMD Ground System 6B1.5 (GS 6B1.5)	Midcourse	N/A	N/A	3	3
Aegis BMD 3.6	Midcourse (SM-3)	5	4	4	N/A
	Terminal (SM-2)	4	N/A	N/A	N/A
Aegis BMD 4.0	Midcourse (SM-3)	4 ➡ 5	4 ➡ 5	1	N/A
Aegis Baseline 9.B1/C1	Midcourse (SM-3) Terminal (SM-2/-6)	1 ➡ 4	1	1 N/A	N/A
Aegis Baseline 9.B2/C2	Midcourse (SM-3)	1	1	1	N/A
THAAD Configuration 1	Terminal	5	4	1	N/A
THAAD Configuration 2	Terminal	3	4	1	N/A
Patriot Post-Deployment Build 6.5.2 (PDB-6.5.2)	Terminal	6	6	N/A	N/A
Patriot Post-Deployment Build 7 (PDB-7)	Terminal	6	6	N/A	N/A
Patriot Post-Deployment Build 8 (PDB-8)	Terminal	1	1	N/A	N/A

Aegis BMD 3.6.1, Aegis BMD 4.0, THAAD Configuration 1, and Patriot PDB-7 are the currently deployed autonomous combat systems providing BMDS capabilities against SRBMs and MRBMs. They are the most mature BMDS weapon elements and, accordingly, have demonstrated testing against their assigned threat classes at Level 4 or higher. Aegis BMD 3.6.1 and 4.0 have the added capability to engage IRBM threats as well. THAAD Configuration 1 has had more flight testing conducted against SRBM targets compared to MRBM targets so its demonstrated capability against SRBMs remains higher than that against MRBMs. IRBMs are part of the THAAD threat set, but neither THAAD Configuration 1 nor THAAD Configuration 2

has been flight tested against them. The GMD element was deployed in 2004 as part of an Initial Defensive Operations concept to provide an emergency missile defense capability if needed. An inventory of GMD interceptors was purchased and deployed to provide this emergency capability before sufficient testing had been completed to quantitatively assess GMD effectiveness. To date, GMD testing still has not demonstrated capability beyond Level 3 despite having a limited combat capability.

Short-Range Ballistic Missiles (SRBMs)

Figure 4-2 shows the history of SRBM demonstrated testing since 2010 and includes the FY/CY14 DOT&E assessment.

Sea-Based Combat Systems. The MDA demonstrated Aegis BMD 3.6.1 midcourse defense capabilities against SRBMs at Level 5, as shown in Figure 3-3. Level 6 was not warranted because Aegis BMD 3.6.1 did not demonstrate SRBM defense capabilities in an integrated operational flight test at the system level, although it did engage MRBM surrogates in both FTI-01 (FY13) and FTO-01 (FY13). Additionally, Aegis BMD 3.6.1 did not demonstrate SRBM defense capabilities for a broad range of downrange and cross-range intercept locations, which are needed to verify the system's performance across the applicable battlespace. Following the period of combined DT/OT testing, a limited set of M&S runs-for-the-record was performed with accredited models for analysis purposes, supporting the Level 5 rating. The MDA demonstrated Aegis BMD 3.6.1 sea-based terminal capabilities with modified SM-2 Block IV missiles only at Level 4 because the suite of M&S tools was not accredited for performance studies following the two DT/OT sea-based terminal flight tests.

Aegis BMD 4.0 completed IOT&E flight testing for its midcourse defense mission in FY/CY14. The high-fidelity M&S tools for assessing SRBM engagement capabilities for the 4.0 system were accredited by COTF so Level 5 capability demonstration is now warranted. However, the M&S accreditation is applicable only over a portion of the overall engagement battlespace. Also, no BMDS-level flight testing with the 4.0 system has been conducted. Thus, Level 6 is not warranted.

The ACS BL9.B1/C1 was intercept flight tested for the first time in FY/CY14. That test intercept flight mission against a simple-separating SRBM target supports a capability demonstration rating of Level 4. M&S analyses covering a good portion of the SRBM-relevant battlespace are needed to achieve Level 5. The ACS BL9.C2 system is in the early stages of development and has not been tested against live ballistic missile targets. Consequently, it is assessed at Level 1.

Land-Based Combat Systems. THAAD Configuration 1 demonstrated testing against SRBMs remained at Level 5. No SRBM flight testing has been conducted since FTT-12 in October 2011, but the program continues to advance through ground testing. Testing of some aspects of SRBM defense also remains incomplete. A number of THAAD Configuration 1 models and simulations achieved limited accreditation for performance against SRBMs from ATEC. Production of THAAD Configuration 1 components continued, and inventory levels are sufficient for limited combat operations.

THAAD Configuration 2 maintains THAAD Configuration 1 capabilities while adding debris mitigation algorithms, more developed training devices and simulations, and missile handling improvements such as a missile canister cold kit and a re-designed missile canister leak indicator. It was flight tested for the first time in FY13 during FTO-01. Although the target was an MRBM, several aspects of the test were equally applicable to SRBM defense. This warranted raising the capability demonstrated to Level 3 in FY13. Since then, THAAD has not conducted any flight testing to demonstrate any increase in capability. THAAD Configuration 2 is currently only deployable on an emergency basis.

Patriot is a fielded operational system managed by the Army. The currently deployed version of Patriot is PDB-7, which has demonstrated testing at Level 6. PDB-7 gives Patriot a capability to use new PAC-3 Missile Segment Enhancement (MSE) interceptors and improves debris mitigation, search, tracking, classification, and engagement functions. PDB-8 will provide Patriot with the additional capability to employ the MSE interceptor and will improve debris mitigation, search, tracking, classification, engagement, and electronic countermeasures mitigation. PDB-8 IOT&E is scheduled for 4QFY16 to 3QFY17, followed by a fielding decision in 1QFY18.

Medium-Range Ballistic Missiles (MRBMs)

Figure 4-3 shows the history of MRBM demonstrated testing since 2010 and includes the FY/CY14 DOT&E assessment.

Sea-Based Combat Systems. The MDA demonstrated Aegis BMD 3.6.1 midcourse defense capabilities against MRBM threats at Level 4. This demonstration of capability was made primarily against ballistic missile targets flying maximum SRBM ranges, but those targets had MRBM characteristics and were representative of the threats expected in the North Korea and Middle East theaters. Such threats represent only the lower-range threshold of MRBMs. An increase to Level 5 was not warranted because the M&S suite for Aegis BMD 3.6.1 was not accredited for performance analyses across the majority of the MRBM threat battlespace, due to lack of data from flight testing against targets above 1,000 kilometers in ground range.

Aegis BMD 4.0 completed its IOT&E flight test program in FY/CY14, and the suite of high-fidelity models and simulations for that system was accredited. A reasonable portion of the battlespace was sampled by the flight test program and M&S, yielding a Level 5 rating. However, parts of the battlespace cannot yet be assessed due to limited data, especially from engagements against targets greater in range than 1,700 kilometers. Hence, a Level 6 rating is not warranted.

ACS BL9.B1/C1 and BL9.B2/C2 systems, which include the capability to engage MRBMs, have not been flight tested. A Level 1 rating remains.

Land-Based Combat Systems. THAAD Configuration 1 demonstrated testing against MRBMs remains at Level 4. THAAD Configuration 1 has previously performed one flight test against an MRBM and two flight tests against a target with MRBM characteristics flying a maximum SRBM range. With only one true MRBM test point, however, THAAD cannot advance directly to Level 5, since testing and accreditation are still limited.

THAAD Configuration 2 was flight tested for the first time in FY13 against an MRBM, which allowed the demonstrated testing for MRBMs to increase from Level 1 to Level 4. Several key characteristics of THAAD Configuration 2 were not demonstrated during the test, so it cannot advance directly to Level 5. No additional flight testing against MRBMs occurred in FY14, so THAAD demonstrated capability remains at Level 4. THAAD Configuration 2 is also currently only deployable on an emergency basis.

The Patriot demonstrated testing level against its MRBM threat set is assessed to be the same as for SRBMs discussed previously.

Intermediate-Range Ballistic Missiles (IRBMs)

Figure 4-4 shows the history of IRBM demonstrated testing since 2010 and includes the FY/CY14 DOT&E assessment.

Sea-Based Combat Systems. Aegis BMD 3.6.1 is the only version of Aegis BMD with a flight test demonstration of IRBM defensive capability. Aegis BMD 3.6.1 demonstrated a capability against IRBMs in FTM-15 (FY11), which was designated as an operational test for Aegis BMD 3.6.1. As a result, Aegis BMD 3.6.1 was assigned a Level 4 rating. A Level 5 rating was not given because the high-fidelity M&S suite was not accredited and used for performance analyses against IRBM threats.

Aegis BMD 4.0 has not been flight tested against IRBM targets. Thus, its demonstrated testing is assessed to be at Level 1. ACS BL9.B1/C1 and BL9.B2/C2 have also not been flight tested against IRBM targets. Hence, their assessments are similarly Level 1.

Land-Based Combat Systems. In FY/CY14, the GMD demonstrated testing level against IRBM threats remains unchanged at Level 3 from prior years. The MDA demonstrated a GMD capability against IRBMs in intercept flight tests: FTG-02 (FY06), FTG-03a (FY07), and FTG-05 (FY09).[39] The subsequent three intercept flight tests resulted in failures to intercept: FTG-06 (FY10) and FTG-06a (FY11), and FTG-07 (FY13). In FY14, FTG-06b resulted in the first intercept of an IRBM target by a GBI equipped with a Capability Enhancement-II (CE-II) EKV. Although that test resulted in an intercept, the flight test was assessed as developmental test and therefore not sufficient to increase the demonstrated testing level for GMD. For GMD to increase to Level 4, flight testing will need to emphasize operational objectives over developmental objectives. The first GMD intercept flight test against IRBM threats designated as an operational test is currently scheduled for FY19. Increasing to Level 5 also requires extensive ground testing using models and simulations that have been accredited for performance assessment, which has not yet been achieved.

Neither THAAD Configuration 1 nor Configuration 2 have been flight tested against IRBMs, although some ground testing has been done. Hence, it is assessed at Level 1.

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39 In these three intercept flight tests, the MDA used targets with a mixed threat character, namely, IRBM-class boost vehicles that deployed ICBM-like re-entry vehicles (simulated threat warheads).

Intercontinental Ballistic Missiles (ICBMs)

Figure 4-5 shows the history of ICBM demonstrated testing since 2010 and includes the FY/CY14 DOT&E assessment.

Sea-Based Combat Systems. There are no sea-based weapon elements with capabilities against ICBMs.

Land-Based Combat Systems. In FY/CY14, the GMD demonstrated testing level against ICBM threats remained unchanged from prior years. The Level 3 assessment against ICBM threats is based on the same intercept flight tests and rationale cited for GMD demonstrated testing against IRBM threats. To increase this level, the same actions cited for increasing the demonstrated testing level against IRBM threats are required, but applied to ICBM threats.

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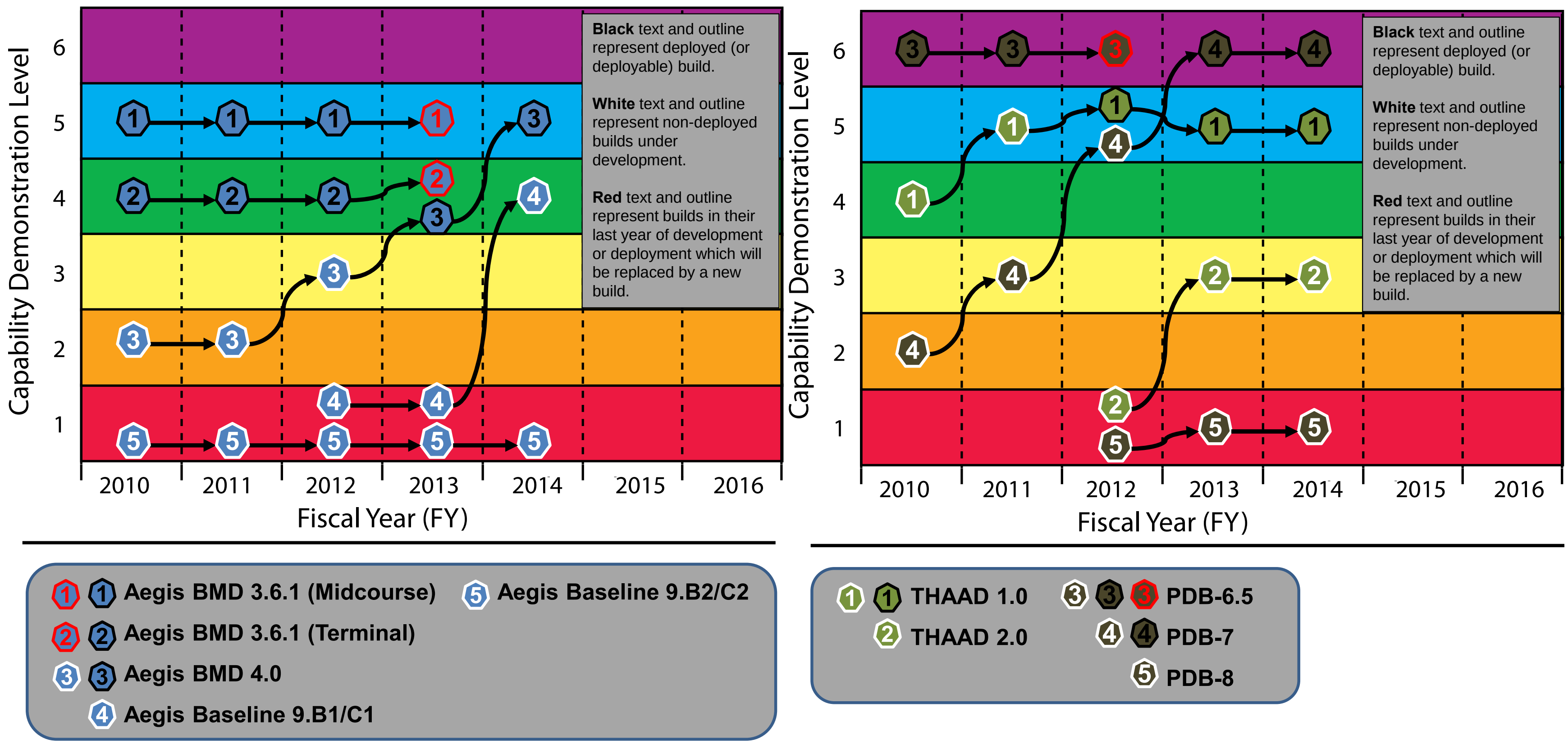
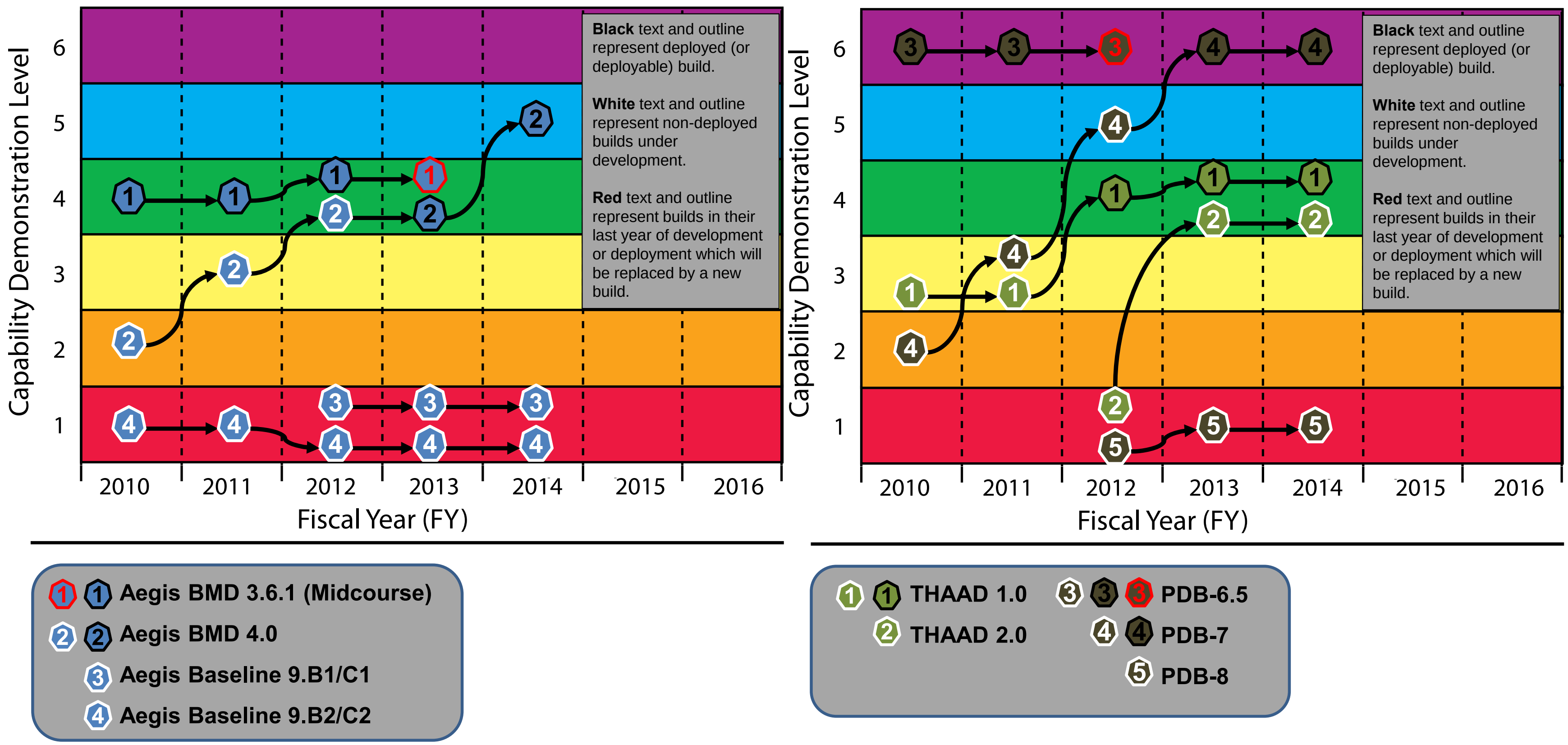


Sea-based Autonomous Combat Systems

Land-based Autonomous Combat Systems

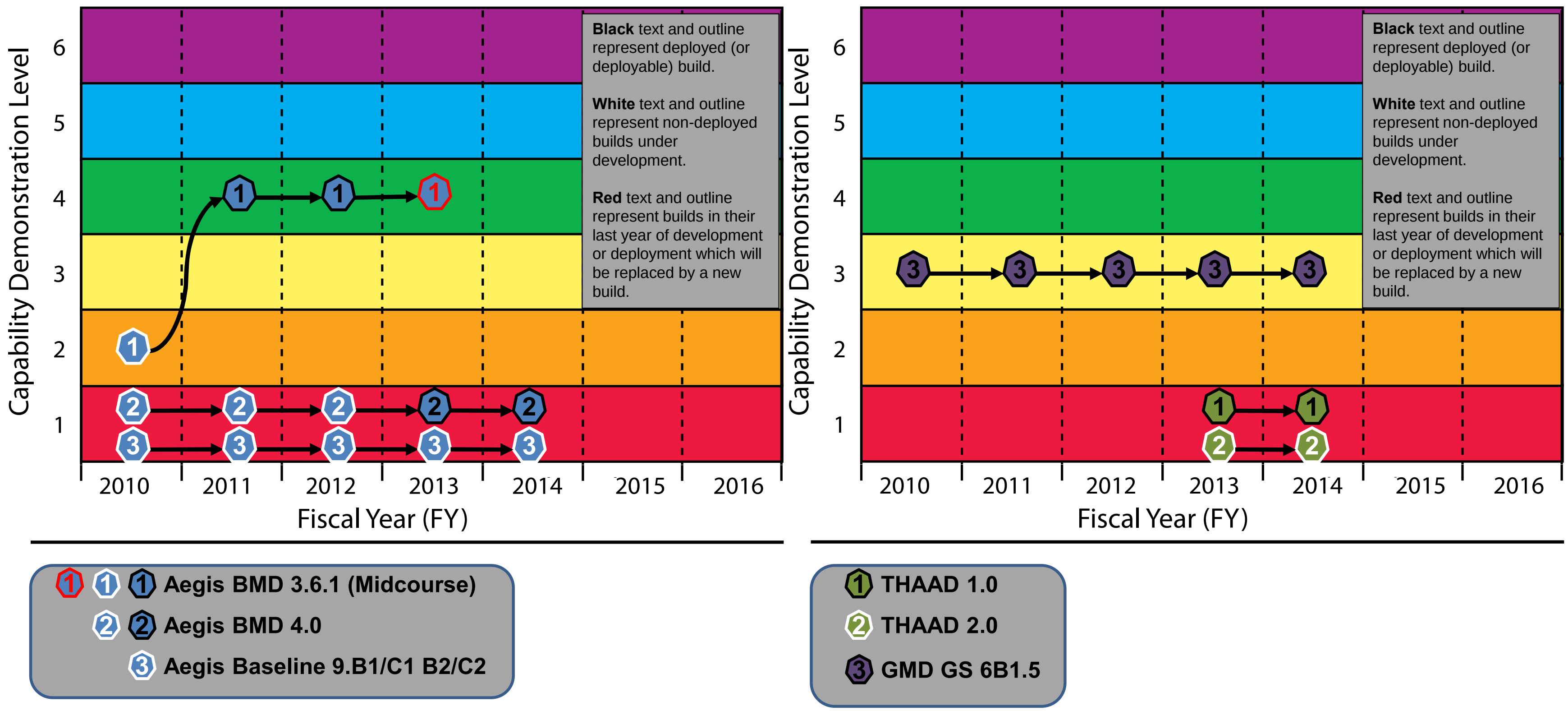
Figure 4-2. Demonstrated Testing for SRBMs



Sea-based Autonomous Combat Systems

Land-based Autonomous Combat Systems

Figure 4-3. Demonstrated Testing for MRBMs

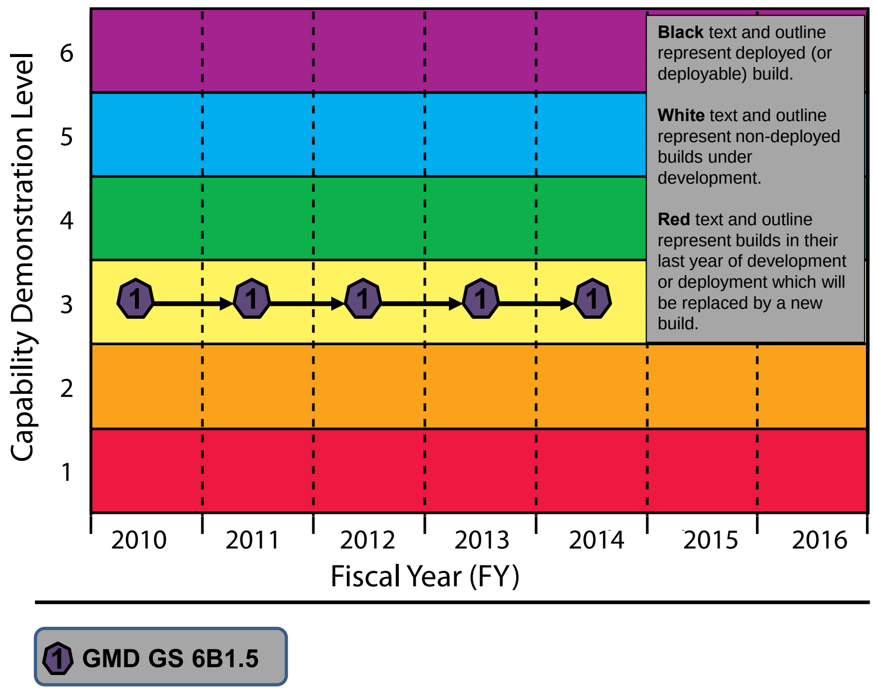


Sea-based Autonomous Combat Systems

Land-based Autonomous Combat Systems

Figure 4-4. Demonstrated Testing for IRBMs

NONE



Sea-based Autonomous Combat Systems

Land-based Autonomous Combat Systems

Figure 4-5. Demonstrated Testing for ICBMs

List of Classified Appendices

The data in this report are supplemented in a series of classified appendices. All conclusions and recommendations are derived from both the unclassified and classified information presented. The following gives a list of the classified appendices produced. They are provided under separate cover.

Appendix	Title
A	Supplement Description for the Ballistic Missile Defense System
B	Supplement Assessment for Operational Effectiveness, Operational Suitability, and Survivability
C	Supplement Assessment for BMDS Test Program Adequacy
D	Ground-based Midcourse Defense (GMD) Flight Test Summary (FY09-14)

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List of Acronyms

AA	Aegis Ashore
AAMDTC	Aegis Ashore Missile Defense Test Complex
AAW	Anti-Air Warfare
ACS	Aegis Combat System
ADAFCO	Air Defense Artillery Fire Control Officer
AFB	Air Force Base
AOR	Area of Responsibility
ATEC	Army Test and Evaluation Command
BCN	BMDS Communications Network
BL	Baseline
BMD	Ballistic Missile Defense
BMDS	Ballistic Missile Defense System
BOA	BMDS Overhead Persistent Infrared Architecture
C2BMC	Command and Control, Battle Management, and Communications
CCMD	Combatant Command
CDD	Capability Development Document
CDU	COBRA DANE Radar Upgrade
CE	Capability Enhancement
CG	Guided-Missile Cruiser
CLE	Command Launch Equipment
COTF	Commander, Operational Test Force
CRBM	Close-Range Ballistic Missile
CTV	Controlled Vehicle Test
CY	Calendar Year
DDG	Guided-Missile Destroyer
DoD	Department of Defense
DOT&E	Director, Operational Test and Evaluation
DSP	Defense Support Program
DT	Developmental Test
EKV	Exo-atmospheric Kill Vehicle
EPAA	European Phased, Adaptive Approach
ESS&T	Engagement Support Surveillance and Tracking
FBM	Forward-Based Mode
FT	Flight Test
FTG	Flight Test, GBI
FTI	Flight Test, Integrated
FTM	Flight Test, Standard Missile
FTO	Flight Test, Operational
FTT	Flight Test, THAAD
FTX	Flight Test, Other
FY	Fiscal Year
GAO	Government Accountability Office

GBI	Ground-Based Interceptor
GEM	Global Engagement Manager
GFC	GMD Fire Control
GMD	Ground-based Midcourse Defense
GS	Ground System
GTI	Ground Test, Integrated
HWIL	Hardware-in-the-Loop
IAMD	Integrated Air and Missile Defense
IBCS	IAMD Battle Command System
ICBM	Intercontinental Ballistic Missile
IMTP	Integrated Master Test Plan
IMU	Inertial Measurement Unit
IOT&E	Initial Operational Test and Evaluation
IRBM	Intermediate-Range Ballistic Missile
LMMT	Link Monitoring Management Tool
LUT	Limited User Test
MDA	Missile Defense Agency
MEADS	Medium Extended Air Defense System
MR	Maintenance Release
MRBM	Medium-Range Ballistic Missile
M&S	Modeling and Simulation
MSE	Missile Segment Enhancement
NATO	North Atlantic Treaty Organization
NDAA	National Defense Authorization Act
OIF	Operational Iraqi Freedom
ORTS	Operational Readiness Test System
OT	Operational Test
OTA	Operational Test Agency
PAC	Patriot Advanced Capability
PDB	Post-Deployment Build
RKV	Redesigned Kill Vehicle
RV	Re-entry Vehicle
S	Spiral
SBIRS	Space-Based Infrared System
SBX	Sea-Based X-band
SCDPTV	SM-3 Cooperative Development Propulsion Test Vehicle
SM	Standard Missile
SRBM	Short-Range Ballistic Missile
THAAD	Terminal High-Altitude Area Defense
TM	Terminal Mode
TSRM	Third-Stage Rocket Motor
UEWR	Upgraded Early Warning Radar
TU	Threat Update
U.S.	United States

USCENTCOM	United States Central Command
USEUCOM	United States European Command
USNORTHCOM	United States Northern Command
USPACOM	United States Pacific Command
USSTRATCOM	United States Strategic Command
UTCO	Upper Tier Coordination Officer
VV&A	Verification, Validation, and Accreditation

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DEPARTMENT OF DEFENSE

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